10 16 25 49 50 60
32 61
38
42 44

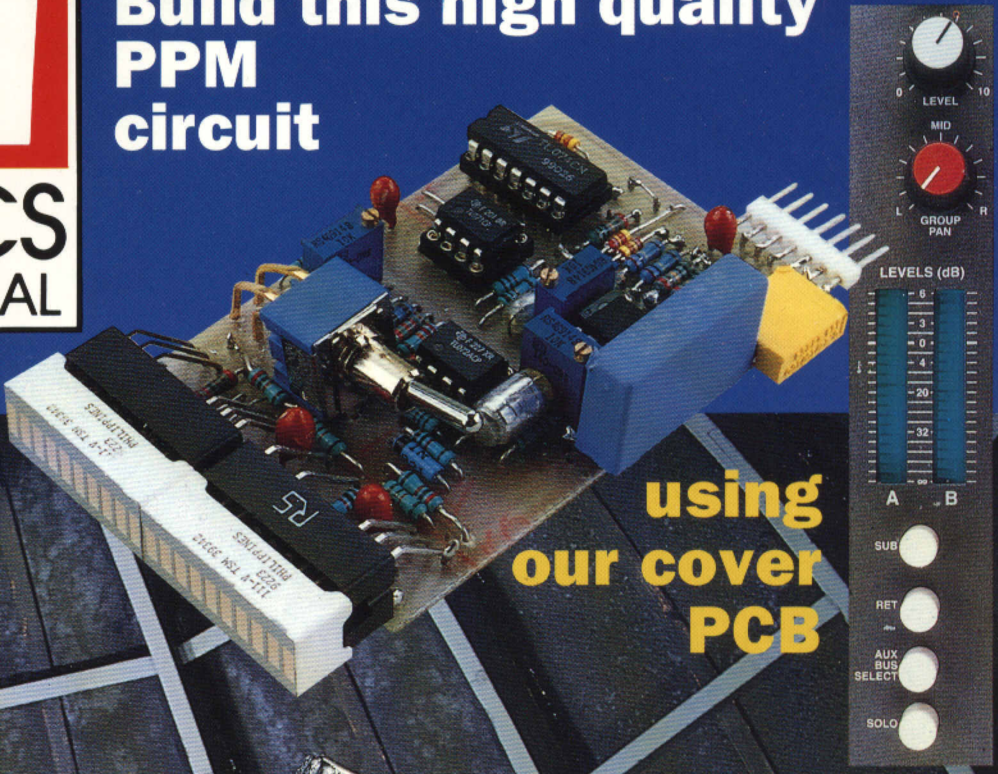
ETI

ELECTRONICS TODAY INTERNATIONAL

APRIL 1993 £1.95

ELECTRONICS, COMPUTERS, TECHNOLOGY

Build this high quality PPM circuit



using our cover PCB

MULTI-MATE
A versatile indicator for the workshop

LIQUID CRYSTAL DISPLAYS

HANDY BAG ALARM

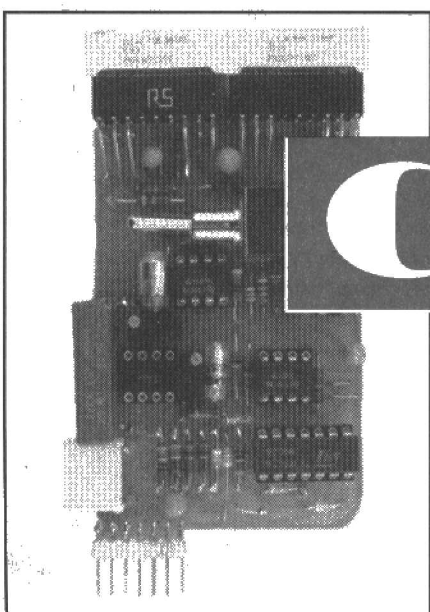
REMOTE CONTROLLED TELESCOPE SERVO

NO PCB?
ASK YOUR NEWSAGENT

04
9 770142 722023

Volume 22 No.4
April 1993

Features & Projects


Page 32

Contents

Regulars

Editorial

by Paul Freeman

The latest news about digital television (page 12) looks encouraging. The most remarkable thing about it all is the high reduction in radiated transmitter power required for a good signal. Digital transmissions are efficient and it should certainly help to reduce electromagnetic pollution. If digital TV test transmissions commence in a few years time and there is no reason to suspect that they will not, wide screen high definition systems will be the *de facto* standard. The inevitable road towards a digital system for TV will ultimately give us increased flexibility in its usage. As mentioned before, the TV of tomorrow will be an audio-visual computer. However, the digital link between transmitter and receiver could eventually be a two way option, leading the way to interactive TV. The first major use would be by the TV programmers themselves. They would be quick to adopt the instant opinion poll. This might lead to a voting system for elections.

If TV remains a national publically-owned service, any increased facilities offered by a digital network might also be used by government to send out things like census forms or a whole manner of printable data on an available channel. Speaking of which, spare channels could be used for sending 'time compressed' programmes to record by paying subscribers.

Fantasy or not, the TV of tomorrow will be a very different beast.

OPEN CHANNEL

Philips faces a new and, ultimately, serious contender against its race to develop the standard for multimedia consumer applications. We're talking CD-ROMs here and Philips' dream of its CD-i as being the only one people will buy.

CD-i's already here of course, albeit in only first-generation form. Philips fair tripped along to get to market with it - I don't suppose it takes much to figure out that other developers would be trying to make their systems the consumer standard also. Generally, though not always, the first of any new electronic devicetype which gets to the public eye becomes the public's choice. You've only got to consider any recent electronic consumer development to see this.

But multimedia is a bit different. Philips has channelled CD-i down the corridor it expects all similar multimedia developments to go. For a start, it's a logical and straighforward development of CD-ROM. And yes, no-one can argue against the fact that CD-ROM (at least for the foreseeable future) is the only form of digital storage device which can offer massive data size along with reasonable access time. Also, CD-ROM can be interfaced with computers and televisions alike.

So CD-ROM it is. But where the multimedia developments differ is in the application of the thing. CD-i uses a fairly standard computer architecture. Currently CD-i and, for that matter, all CD-ROM application speed depends on hardware technicalities. Faster CD-ROM drives allow correspondingly faster performance. But multimedia performance is ultimately based on graphical imagery; renowned for its large-scale need for processing power. So while CD-ROM drives get faster the point is approaching where the processing side of any particular development will define the performance.

Sure, Philips can rejig the architecture when this point is reached, but that's a colossal undertaking (and one which no doubt Philips is already considering, if not already doing) adding further development costs.

The new challenger to Philips' vision of multimedia is a company called 3D0, which has shown a new CD-ROM based device built around an ARM 32-bit RISC processor. And yes, before you ask, that's another of our very own Cambridge-based chip maker Advanced RISC Machines' devices. I've mentioned the name in passing when I've spoken of other new and imaginative electronic devices.

Portable Power

For those of you who remember my antics last summer, when I spent considerable time touring Eire in a caravan while getting my copy to ETI by fair or foul means, I've something else to add.

Since then I've succumbed to my urge to gather as many gadgets around me as a I can, and bought a notebook computer. Thankfully I can justify the expense in terms of needing it to work away from home - particularly, when I'm away from mains power. The notebook's superb at this, giving me around four hours of use away from a recharge. I'll be taking it with me on this year's summer touring escapades. Armed with my new computer I should be able to bypass the power problem, recharging from mains whenever I can and faxing through any copy I write the odd times I come into contact with a 'phone socket. Despite it's wild beauty, Eire's not that remote.

However, a reader in South Africa has written to me regarding computer use in a part of his world which most definitely is remote. Remote enough, in fact, not to have mains power at all - or where power is available it's by no means regular enough to rely on it daybyday. As he says "even our modern portable computers are portable for perhaps 4 or 5 hours at the most. All right, take along half a suitcase full of rechargeable battery packs and you might extend that by a day or two."

He's right of course. Even I will come up with the problem once I've used my computer away from mains for my 4-hour limit. I'm sure there're many more computer users in the world with this problem. Do readers have sensible suggestions? Maybe some readers could suggest projects to build rechargeable battery chargers for portable computers, or 12V DC to 240V AC inverters for desktop computers.

Barking Mad

Finally, I'm going to bring to a close the on-running saga about dog repellers. I can't say that I've had no suggestions about how to repel potentially savage dogs. In fact quite the opposite; I've had many suggestions. Most of these though are based on physical aspects, some of them I will not repeat. But all these suggestions fall down one way or another (maybe the dog can run faster than you).

You'll be interested to know that this single topic has provoked more interest from readers than any other topic I've ever covered in this column. I'm not quite sure what, but this has got to mean something! The main problem is, however, none of the suggestions offered by readers is electronic. And that was the original request. I've even had difficulty in finding details of any manufactured and available electronic dog repellers. One reader alone indicates there may be devices on the market which purport to do the job. Apparently he bought one a few years' back to help train his border collie from his furious barking (the dog's that is, not the reader's). Far from doing this, the dog barks even more when the device is used. I've had no success in tracing the device's manufacturer despite the reader's help.

I'm still not convinced it can't be done, though. I mean, we've landed on the moon (collectively, at least) haven't we? Surely an electronic dog repeller which actually works is - like the dog's bits and bobs - within our grasp. Isn't it? After all, the Post Office issues devices to its personnel. So why can't anyone help with a working device suitable for an electronics magazine? However, unless any readers really do have a design for a good electronic dog repeller project, I'm afraid the matter is now closed.

Keith Brindley

VIRTUAL REALITY COULD TRANSFORM BUSINESS

New applications for virtual reality technology that could transform the way we do business were outlined at a seminar held by Peter Cochrane, the head of the Systems Research Division at BT Laboratories, Martlesham.

Virtual reality (VR), a technology where the user experiences a sense of involvement in a computer-generated graphical world, is usually associated with the entertainment and games industries.

BT, however, is taking VR several stages further by developing it as a tool for understanding and managing complex business and electronic systems.

At the seminar, BT demonstrated four VR applications - Telepresence, Data Visualisation, Emotional Icons, and Flying a Communications Network.

Potential Telepresence applications could include mobile teleworking between head office and service centres, medical applications such as the direction of operations from remote locations and electronic news gathering where one reporter combines the roles of cameraman, soundman and commentator.

Other Telepresence developments could include a pointing facility that allows the remote observer to indicate features of interest to the user and hands free interaction with databases using voice commands.

Visualisation techniques use advanced graphics to assist data interpretation. At the seminar, Cochrane showed how such techniques can be used to build up a picture of lightning strike patterns as they affect a telecommunications network, so that protection measures can be more easily formulated. He stressed that animated 3D colour graphics make complex and important information far more accessible. Emotional Icons would provide a humanised interface with data in network control applications and can also be linked to artificial intelligence to assist decision making.

Flying a Communications Network overcomes the time and logistics problems involved in network management: a 'desk-top' virtual reality system can provide a network manager with a tool for observing and interacting with a 3D representation of a layered network structure.

Outlining BT's role in virtual reality research, Cochrane said: "BT Laboratories is committed to research work that helps us to anticipate the business communications requirements of our customers. We believe that virtual reality will become an increasingly important technology because it makes the assimilation of complex business information a faster and easier process."

"INNOVATE OR LIQUIDATE" SAYS A CBI/DTI REPORT

The key to increased competitiveness and profitability lies in the hands of British business - according to the findings of the first joint investigation by the Confederation of British Industry and the Department of Trade and Industry into the state of innovation in UK companies.

On Wednesday 27 January, around 400 leading industrialists heard the stark message 'innovate or liquidate' at the launch of a report entitled 'Innovation - The Best Practice'.

The study, which involved in-depth interviews with 76 companies from manufacturing and services, revealed that one UK company in every ten is a world class innovator and three in ten are good at many aspects of innovation, although there is room for improvement.

The report shows that companies which scored high on innovation were also those which were continuing to grow and prosper despite the recession. The reasons for their success have been carefully analyzed and the publication of the report is intended to spread innovation best practice throughout Britain.

The study also shows that innovative firms tend to have much larger market share, higher growth rates and profits than poor innovators. It suggests that if more UK firms improve their innovation performance, Britain should be able to climb up the international competitiveness scoreboard, on which it currently lies 13th out of 22 OECD countries.

Michael Heseltine, President of the Board of Trade said:

"This in depth analysis represents a snapshot of current best practice on innovation within UK industry. There is no question of it being Government imposed, or another bureaucratic exercise. The report reflects what the best British companies - from small concerns to large enterprises - have found out for themselves and are now adapting in ways best suited to their own circumstances. The outcome is a distillation of current best practice, capable of producing a winning formula for all UK businesses.

"Innovation is clearly a vital component in improving the competitiveness of business, both in the manufacturing and the service sectors. Contrary to popular myth, it is not just about spending large sums of money on research and development. As highlighted throughout this report, innovation begins with people.

"The report shows that in many cases a change in corporate culture has proved necessary to the promotion of innovation. Communication and team working - involving staff at all levels of the business - emerge as the key ingredients."

The President also announced that Innovation is to be featured in DTI's 'Managing in the 90's' programme. An innovation theme will be included in the events and publications and there will be a series of packages to help business become more innovative.

Howard Davies, Director General of the CBI said:

"Innovation is a way of life in the most successful companies, which are continually asking themselves, 'Are we doing things the right way?' and 'Can we do them better?'. It is not just invention, although clearly it does involve the development of new products and new processes. It can also involve anything from training and re-training to collaboration with customers, advertising, marketing and distribution".

Other pointers from the report

show that best practice companies are those with a clear sense of mission and purpose, with a strategy balanced between short, medium and long term, thoroughly thought out at board level and communicated throughout the organization. Flatter hierarchies are the norm, and the companies are generally run by chief executives with a strong personal commitment to innovation.

The report says that new ideas are welcomed - often through suggestion schemes - and those which are successful are rewarded by bonuses, prizes, royalties or promotion. No ideas fall on deaf ears and all are regularly reviewed with all relevant departments such as R and D, production, sales and marketing and, in many cases, customers.

Innovation, says the study, is difficult to measure, but leading companies set formal performance targets and they measure performance against their competitors including the world's best.

TOSHIBA YEAR OF INVENTION AWARDS

A new, low cost breathing monitor which aims to save the lives of babies at risk from Cot Death Syndrome, has won top prize in the national Toshiba Year of Invention competition organised by the Confederation of British Industry.

Its inventor, 18 year old Edinburgh schoolboy, Colin Paton, is the youngest ever outright winner of this competition.

The winning monitor, called 'Breathe Sure', is designed to be hung from the cot or pram of a baby at risk. A sensor attached to a cloth belt worn around the baby, picks up the infant's breathing and checks that it is functioning correctly. Each time a breath is detected a green LED flashes to indicate that the alarm is properly tracking the baby's breathing. Should breathing stop or become irregular an alarm sounds.

Colin Paton had his bright idea for the alarm after seeing his baby sister, Katherine, being monitored in hospital after she was born.

Breathing monitors used by hospital baby units cost between £300 and £400. Colin anticipates his monitor will sell for approxmately £60, offering affordable peace of mind to many parents.

As outright winner, Colin received a total £15,000 cash prize, plus the choice of an all-expenses paid trip for two people to Japan and the Far East, or top-of-the-range Toshiba colour computer equipment. Prior to being declared outright winner, he also won the school category.

An industrial designer, Gareth Jones from Bath, won the individual category with a new-design folding bicycle trailer capable of carrying loads of up to 40 kilograms. He hopes the device will persuade more urban drivers to switch to cycles and reduce traffic pollution in Britain's towns and cities.

Winner of the university/college category was a research team from Oxford University, led by Jan Czernuszka. The team has developed the world's first bone substitute material which is capable of stimulating bone growth outside the human body.

A head teacher from Hartlepool and a Stanley businessman won the small business category with their new Floatsation raft which gives total water support and independence to the profoundly disabled. It is also aimed at the leisure market as an aid to relaxation.

A low cost, simple-to-use telephone for people with hearing difficulties also won a major prize at the Year of Invention competition. Richard Mead, a 17 year old Chelterham College sixth former won joint second place in the school category and received £2500. It is Richard's second consecutive success in this competition. Last February he received £5000 as winner of the same category for his Powersave energy monitor.

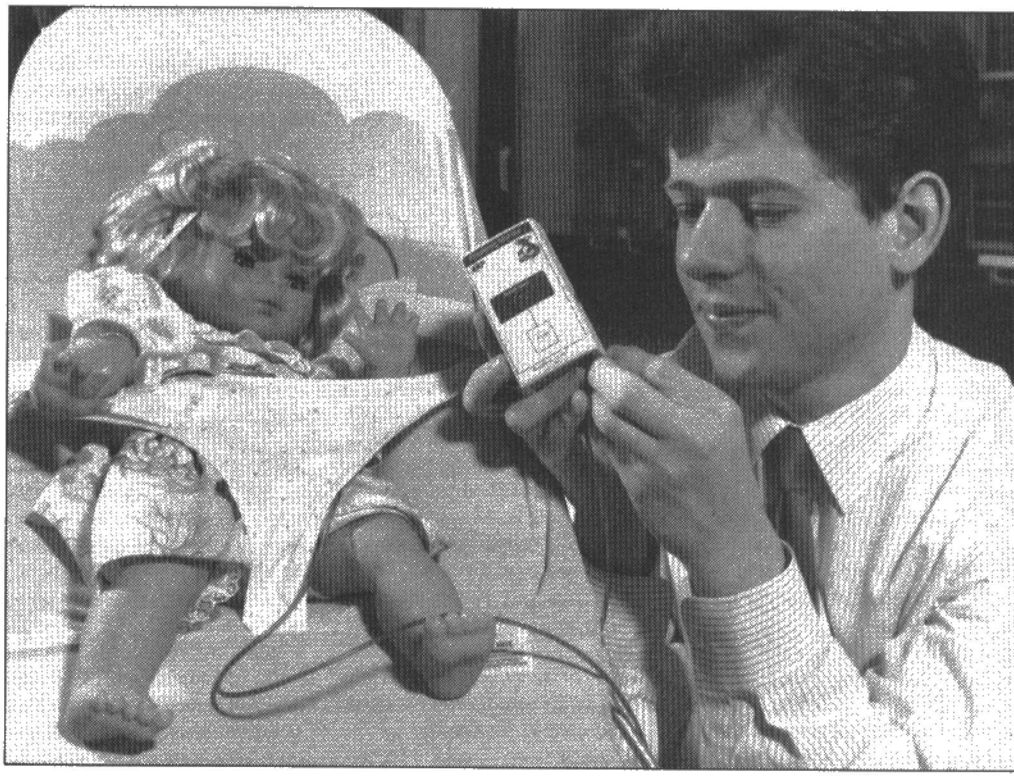
Richard had the bright idea for his new device, which he calls Textcall, when his sister complained about the difficulty she had communicating with a deaf friend outside school time. He claims that his invention is a cheaper alternative to the existing textphone or computer modem links available to people with hearing difficulties.

Textcall requires only one unit at one end of the telephone line. Messages are sent using the dialling tones of an ordinary tone-dialling telephone.

The number keys one to nine on a 12-button key pad of the telephone each represent three letters of the alphabet. The bottom three keys, the star, zero and hash symbols are used to identify which of the three letters was meant. A simple sequence of two presses per letter is used to enable rapid transmission of any alphabet letter.

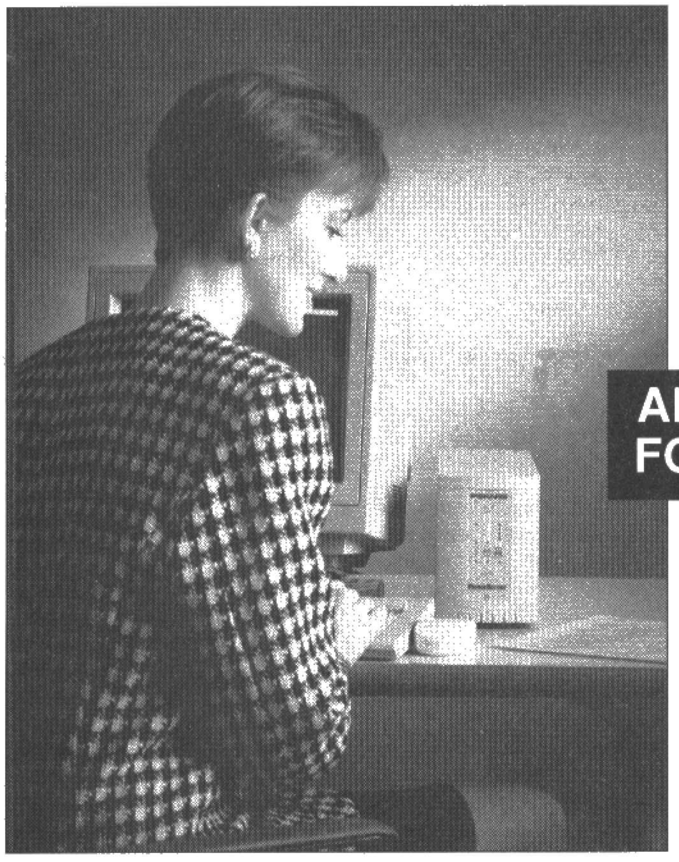
The tone sequences are received by a Textcall unit attached to the ear piece of the non-hearing person's telephone, which decodes these sequences into letters and words, and then displays them so that they can be read. Assuming the non-hearing person can speak and the original sender can hear, the message can be answered verbally. If not, a second Textcall unit can be fitted, enabling two-way communication between two deaf people.

Richard used an ETI project to help him implement his textcall system.



Hoping to study physics at university after leaving Cheltenham College, he developed his Textcall telephone device as a GCSE electronics exam project. Last August he heard that the device had earned him an 'A' pass.

Richard has registered a patent application for the invention and has so far managed to finance the project from his own resources. He has had recent discussions with an electronics company that has expressed a positive interest in developing and marketing Textcall.



PowerServer is a new, low-cost uninterruptible power supply from Fiskars Power Systems. It offers many of the most advanced features of Fiskars' high-end systems to small-computer users on a low budget.

PowerServer provides power filtering and conditioning facilities significantly better than other UPS systems in the price range, as well as computer communications, battery monitoring, and a user-friendly front-panel status display. These features, ensuring reliable computer operations with complete protection for software and data, are far in advance of competitive products.

Intelligent voltage monitoring prevents the load being switched unnecessarily to battery power, but executes rapid transfer when voltage deviations do justify switching to inverter operation.

An automatic orderly shut-down of the computer is also implemented through monitoring of battery parameters and detection of other abnormal conditions.

ADVANCED STANDBY POWER FOR EVERY COMPUTER USER

PowerServer features both an RS232 interface and relay mode communications to ensure that it can communicate mains and UPS status to any host computer.

The PowerServer range offers six models with output power ratings from 400 to 2200VA.

For further information contact: Fiskars Power Systems, Tel: (0734) 306600. Fax: (0734) 305868.

JOINT TECHNOLOGY DEVELOPMENT OF 256MEGAB1T DRAM

Texas Instruments and Hitachi Ltd, have announced an agreement to jointly research and develop a 256-megabit dynamic random access memory (DRAM) integrated circuit beginning in the feasibility stage of the development. This agreement starts with a year long study on the feasibility of co-developing common technology for the 256Mb DRAM, before proceeding with the co-development of the next-generation memory chip.

Under the agreement, TI and Hitachi will share information in each area of process, design, and manufacturing technology for the 256Mb DRAM and each company will have access to the other's technology as it relates to the 256Mb DRAM development.

This new agreement is the third joint effort in memory chip development for the two companies. The first was established in December, 1988 to develop a common technology for the 16Mb DRAM. TI and Hitachi further strengthened the relationship in November, 1991 with the announcement of an agreement to jointly develop a 64Mb DRAM.

Feature size of the 256Mb DRAM will be 0.25 microns. By comparison, a human hair is 76 microns in width. The smaller the feature size (or gate) of a memory chip, the more information that can be stored on the chip.

The 256Mb DRAM will be capable of storing 256 million bits of information, equivalent to 11,200 typed pages of text. This is four times the amount of information than the previous generation of memory chip, the 64Mb DRAM, contains. The 64Mb DRAM will be capable of storing 2,800 pages of text.

Work on the 64Mb DRAM is on schedule at TI's Miho facility and Hitachi's Device Development Center in Japan. The joint development team has completed a product design and is currently producing the memory chip prototypes. Next, the two companies will jointly develop and produce first generation chips.

Both the 64Mb and 256Mb DRAMs are next-generation memory chips. Today's systems use 4Mb DRAMs. TI has been in volume production of 4Mb DRA]Ms since 1990 at its wafer fabrication plant in Miho, Japan and since 1992 at Avezzano, Italy and its joint venture plant with Acer in Taiwan.

Industry analysts predict that shipments of 4Mb DRAMs will peak in 1994 at approximately 700 million units.

LOWER MICROWAVE CHIP COSTS

The University of Kent at Canterbury, Philips Microwave and Barnard Microsystems have joined forces in a collaborative project to develop computer-based design tools to halve typical development costs of very high-frequency microchips.

These microchips (called Gallium Arsenide (GaAs) Monolithic Microwave Integrated Circuits (MMICs)), are already at the heart of various electronic systems. They are critical to the future of the communications industry, particularly in such applications as miniature personal telephones, direct broadcast satellites and global positioning systems. They will also be vital components of anti-collision and navigational systems of the cars of the future, already tested on the roads of Germany and Japan.

"Currently an average MMIC design requires four to five man-months and the processing cost is about £40,000-£50,000" said Keith Williams of Philips Microwave. "To achieve a true explosion in MMIC applications, it is essential that a more accurate, economical method of producing the MMIC is developed and the design costs are reduced. Philips is excited about the collaboration with the University of Kent and Barnard Microsystems and see it as the way ahead in this developmental process."

The team, with the help of a £1,437000 grant from the Department of Trade and Industry, is developing a comprehensive design package which will include accurate models of MMIC components, plus all the elements required in the design process, built into a single work station. "At present, the combination of process spread and insufficient accuracy of computer simulation often

makes it necessary to repeat the design loop two or even three times before the chip is constructed. With each design loop taking several months and costing over £50,000, the envisaged savings both in time and money will be very substantial" said Adam Jastrzebski, Senior Lecturer in Electronic Engineering and leader of the GaAs Research Group at the University of Kent.

The new MMIC design software package and the improved modelling methods will allow much more accurate prediction of the chip's performance. This, when coupled with the simultaneous tightening of the process control by Philips and other GaAs foundries, should result in "right first time" designs and should at least halve typical MMIC development times and costs. The chips will not only be cheaper but also the products using them will reach the market place much faster.

The MMIC design software will be converted into a commercial product by Bamard Microsystems. Adam Jastrzebski said, "I foresee our software being used by engineering companies throughout the world.

For further information please contact Helen Harrison or James Adamson at The University of Kent.

ACTIVE CROSSOVER FROM BK

BK ELECTRONICS have announced the launch of the XO3 programmable 3-way active crossover. The XO3 is a stereo cross-over unit, with many features. Housed in an industry-standard 19", 1U high rack case, the X03 has a removable front fascia panel, behind which are the DIP switches for programming the unit's cross-over points. Levels for bass, mid and top are fully adjustable, with phase invert switches on the bass channels. The XO3 achieves 24dB per octave cross-over slope.

The XO3 programmable 3-way active cross-over is available at the price of £116.33 including VAT, plus £7.00 delivery, from B.K. Electronics. Tel: 0702 - 527572 Fax: 0702 - 420243.

ANOTHER PERSONAL COMPUTER REVOLUTION

The personal computer is set to revolutionise our lives all over again, with PCs "taking a place in every house, car and handbag", according to Paul Mugge, the head of IBM's research and development laboratory at Boca Raton, Florida.

Mr Mugge was speaking at a press conference in London to mark the tenth anniversary of the UK launch of the IBM PC, which was developed at the Boca Raton laboratory. He said that in the next ten years we will see:

÷palm-sized computers that send and receive information from anywhere in the world, computers capable of human conversation. and all-in-one entertainment, information and communication systems in the home that will take the place of compact disc players, video players, cameras and computer game machines.

Mr Mugge explained that although most of the technology is already available and will reach consumers in the next two to three years, even more exciting developments lie around the comer. His current work centres on the way in which the PC will become truly "personal technology".

He went on to say:

"We are about to see personal computing, communications and consumer electronics coming together to provide consumers with machines that until now have been pure science fiction. This has been talked about for a number of years - but IBM is now making these machines a reality.

"The next decade will see the PC leave the desktop and move into the palm of the hand. PCs will be more portable and user-friendly than they are now, will go anywhere that people go and be able to receive and transmit information around the globe. We will be able to talk to computers and replace keyboards with touch sensitive screens or systems.

"Above all, as in the last ten years, we expect enormous strides to be made in the power and capability of the average PC, which will have an even greater impact on our lifestyles and working patterns.

"What is certain is that the technology we can foresee now will be superseded if the pace of development continues at its present rate."

Mr Mugge was speaking at the launch of an IBM report which analyses the impact of the PC over the last decade and gives an insight into what the next decade might bring.

UNIQUE ELECTRONICS TRAINING CENTRE OPENS FOR BUSINESS

Courses have begun at the UK's first centre specialising in the repair of computerised electronic circuits.

The Surface Mount and Radio Technology Centre at Hertford Regional College in Broxbourne, Hertfordshire, offers a range of short courses including the repair of printed circuit boards and of analogue and digital mobile phones. The only other centre of its kind is in Holland.

Equipment for the centre has been purchased with two El 15,000 grants, from Hertfordshire TEC and Hutchison Telecom. It includes the Marconi 2955B cellular tester and the Marconi 27-2000 SMT rework station.

College principal John Evans said: ÷The centre will enable us to train engineers for a range of hi-tech industries based in the county and beyond, offering courses which will ensure that qualifying students will be among the best trained in the country√.

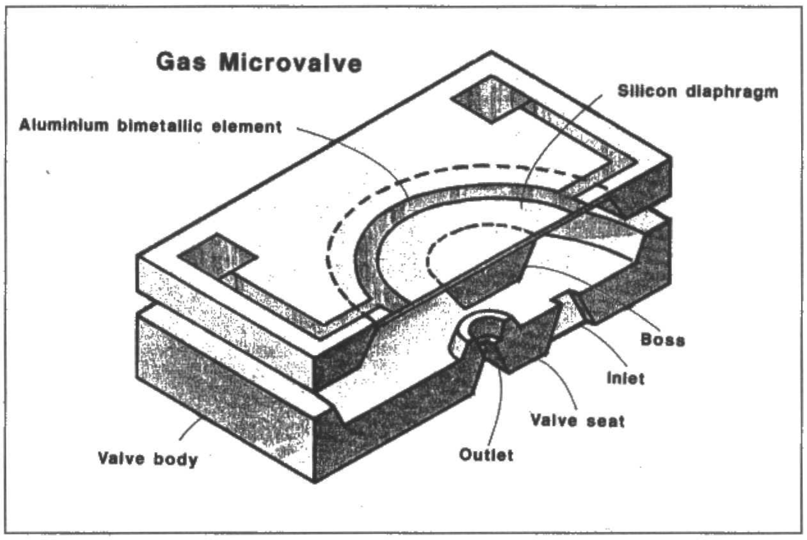
For further infomation about these courses, which lead to National Vocational Qualifications (NVQs) call Paul Dwyer on 0992 466451

ETI

NEWS

...Stateside...

Miniature microvalve



A US company manufactures a very small microvalve using silicon micro-machining. This is a method of batch fabricating minute electronic components with silicon etching and wafer laminating as well as traditional IC-processing techniques.

The normally closed microvalve consists of a silicon diaphragm with a central boss that mates to an etched silicon valve body. A thin aluminium film deposited on the diaphragm forms the other element of the bimetallic structure. Varying the electrical power dissipated by resistors implanted in the diaphragm makes the temperature of the diaphragm change. As temperature increases, the difference in thermal expansion between the silicon and aluminium forces the boss away from the valve seat. The higher the temperature, the farther the valve opens.

Plastic caps bonded to each side of the valve body provide gas connections. The Model 4225 microvalve is only 0.6 x 0.6 x 0.3-inches and weighs 0.3g. It can replace solenoid valves measuring 2 x 1 x 1-inch that weigh 15 to 20 g, yet sells for about one-third the price in OEM quantities. Filters inside the package keep particles from entering the valve chip. Combining microvalves with pressure or flow-sensing elements provides closed-loop pressure or flow control. The microvalve provides fully proportional flow control from 0 to 150 cc/min with an operating pressure ranged of 25 psig. Prototype valves have been cycled millions of times with no observable change in performance.

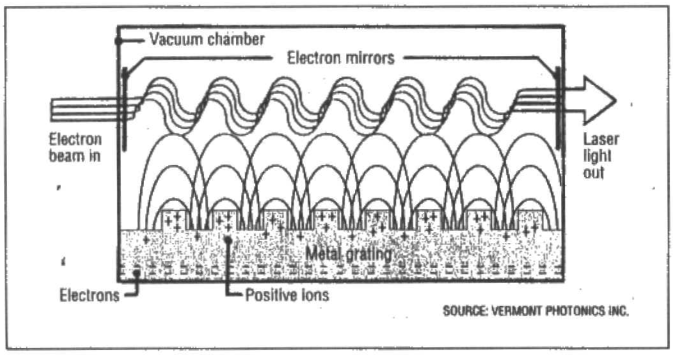
Source: IC Sensors, Milpita, California.

Scanning microscopy

A scanning force microscope has been equipped with a new tip having an unconventional shape by IBM researchers who have used the device for nondestructive inspection, characterisation and profiling of both the width and depth of circuit features. The technique could replace scanning electron microscopy. Rurthermore, with SEMs, a wafer would have to be sliced in half in order to inspect vertical sidewalls.

Because the non-destructive technique may replace such destructive tests the advance has the potential of saving the semi-conductor industry many millions of dollars a year.

IBM said that it will license the technology to metrology companies, and will also offer it as an option with its scanned-probe-microscope tools now being marketed commercially.



Free electron lasers

Research on the principles underlying free-electron lasers are leading to new techniques that promise tunable desktop laser systems. Large-scale laser sources that were developed through programmes such as the Strategic Defence Initiative require a roomful of equipment to generate the million electron-volt beams and intense magnetic fields required to produce laser light from free electrons.

New approaches that use resonant cavities or low-temperature plasmas to scale down the free-electron effect now hold out the promise of practical commercial systems.

Dartmouth College of Hanover, New Hampshire, have joined with Vermont Photonics Inc. to make a scaled-down prototype, according to Vermont's president, Michael Mross.

"We have an exclusive licensing agreement with Dartmouth College," explained Mross, "and in return, we are helping researchers there with the new optical tools we are developing."

The company is basing its product development on a discovery by Dartmouth that high-energy electrons travelling near a metal grating produce coherent radiation. The speeding electrons induce an oscillating charge in the metal grating that reacts with the electron beam to produce coherent light. The effect is amplified by building a resonant cavity around the grating. As the electron beam bounces back and forth over the grating it pumps energy into a light field at a specific frequency, resulting in the classic amplification of stimulating emission that underlies all lasers. The technique completely eliminates the large magnets required by standard FELs and can operate with modest electron-beam energies.

Engineers at Vermont Photonics have also come up with the remaining critical piece of the puzzle for building practical systems - a scaled-down electron-beam source. "What we have come up with is essentially an electron gun that runs on rack-mounted 100-kV DC power supplies," Mross explained. "Our job now is to package the system so that it will be user-friendly and fit on a desktop."

Rather than attempting to build a laser source tunable across a broad range of frequencies, Vermont Photonics has decided to target a gap in the electromagnetic spectrum that falls between microwave and optical technology.

Mross is planning to set up a facility at Dartmouth that chemical researchers could use to pursue infrared spectrographic studies. "With an infrared laser system that is easy to use, we expect the facility to generate momentum in this new area of chemical research, and in the process generate contacts for our commercial systems when they are ready," he said.

READ/WRITE ETI Letters

A Converted Inverter

Refering to the article in ETI December 1992 on the 12V to 240V mains converter, I have the following question.

Would it be possible to use this unit to generate 48V instead of 240V by replacing the transformer.

I don't see why not. Your output voltage is governed by the turns ratio and the efficiency of the transformer. A 1:4 increase on the turns would take you in the right direction for a 48V peak. - Ed.

Digital Heartbeats

As I have a Pacemaker implant (otherwise I would have died 18months ago), I am more than interested in The Heartbeat/Audio listener published in October 1992 and as I have had to periodically check my pulse rate, I wonder if it is in the bounds of possibility to design a circuit using a digital counter?

I and no doubt many others would be extremely grateful if you could publish such a circuit which would eliminate the use of headphones.

J M Whiteley, Ravenstone, Leics.

We are always open to offers from any of our readers who might have a circuit for publication.

Gas Detection

Could I pass on some information to help your readers who are building the Gas leakage detector in Tech Tips Feb '93. The article states "..the sensor must be placed somewhere around the ceiling". Having been a heating service engineer for some 20 years I should point out that some gases are heavier than air and therefore sink to the lowest point, where they can build up to dangerous levels. These gases include two of the most popular fuels, propane and butane as used by caravaners and those that live in the countryside without mains gas. the sensor in these cses should be sited at the lowest point, where they can detect any build up. ie i a caravan at the lowesst point beneath the cooker or in the bilges of a boat.

J G Mepham, Warrington, Cheshire.

Well spotted Mr Mepham - Ed.

Fading Festoonery

An attempt by my stepson to build Richard Sayer's "Fading Festoonery" resulted in the following improvements having to be incorporated:

1. The unclear specification of the transformer in relationship to the foil pattern led to the shop supplying one which needed the PCB to be modified to put both secondaries in series (in our case).

2. C2 needs to be several times the value shown to reduce ripple to a level whose trough does not interrupt the regulator's operation.

3. With the rectified 50 Hz sinewave fed to the comparator, the most power able to reach the lamps would be less than half since the gate pulse cannot advance any earlier than near the sine peak (follow the logic of Richard's Figure 3). A ramp or sawtooth synchronised to the mains is needed. RV1 was removed and replaced by my Figure 1, mounted on a small piece of stripboard above the original PCB.

The 3k3 ensures that the trough of rectified mains reaches zero every half cycle. Q1 is off briefly around the mains zero crossing, letting Q2 discharge the 68n capacitor to a level set by the 510R and 150R. This level is around the lower value at pin 5 of IC1. The time constant of the capacitor with the 150k is chosen to reach the upper voltage at pin 5 in the time Q2 is off (just under mains half cycle time). Since the original R1, R2 and R4 do not change value, the values in the sawtooth generator do not need adjustment so any variable replacing the function of Richard's RV1 is pointless.

4. Following from the correction in part (3) above, the positive gate pulse does not move within the mains phase. Since cutting track to reverse the comparator inputs looked a messy prospect, advantage was taken of the fact that triacs fire in all four quadrants by removing D2 and driving from the negative pulse.

5. The *main* role of a capacitor like C6 (and C9) is NOT, as Richard states, "to smooth the current through the load". It is to protect the triac from being destroyed by turning brought on at the wrong time by the high rate of change of voltage encountered in some switching circuits. By itself it has a drawback in that its peak discharge current can also destroy a triac switch on: Triacs were being destroyed in this circuit until the network of my fig 2 was added. The fuses are redundant as most semiconductors are destroyed in fewer microseconds than an ordinary fuse takes to melt.

6. The user's desire for adjustment is best satisfied by replacing each of R3 and R10 by a 100k preset in series with a 15K.

Despite all the above, Richard's idea was inspired and has provided a novel feature for my wife to show our guests as well as interesting work for myself and stepson.

**Nick Lacey
Reading
Berks.**

Richard Sagar replies:

The smoothing capacitor before the regulator is indead much larger than that stated on the diagram, I have a 100µ capacitor as opposed to the 10µ stated, a typing error somewhere down the line. I noticed also on the published diagram that the inputs to IC1 a are incorrectly labelled (+ and - are the wrong way round), though the pin numbering is correct.

His point regarding the use of a sawtooth or linear waveform for the triggering of the triac is something I had given thought to but in the interest of keeping the circuit compact, and to get across the basic principle of operation, I left the additional circuitry out. My intention would have been to use a constant current source to charge the capacitor, giving a linear change in voltage with time and synchronized to the mains using the same technique as his.

The inclusion of the fuses can do no harm and will protect from shorts.

I am of course encouraged to know that my article was interesting enough to receive some attention.

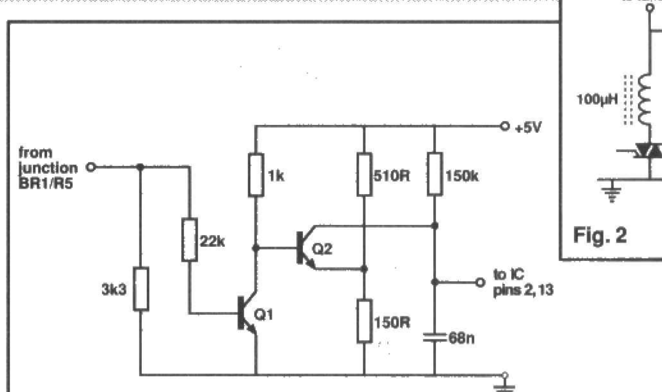


Fig. 1

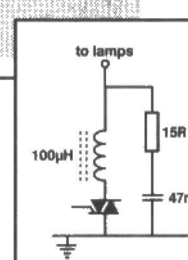


Fig. 2

ETI NEWS SPECIAL

FIRST DIGITAL TV PICTURES FROM DEVON

ETI readers have always been kept well informed on the latest developments in technology and during the last year our series on HDTV not only gave a great deal of detail as to how HDTV works, but also explained about the initial digital test transmissions that were being carried out by the ITC and National Transcommunications Ltd. from existing transmission sites in Devon (ETI August 1992). James Archer now reports on the latest news from Exeter where, at the end of January, live over-air transmissions of widescreen enhanced digital television programmes were demonstrated to top broadcasting executives and to government regulators.

Digital Television - Developments in transmission

We learned last year that ITC sponsored work being carried out in the research laboratories of the UK's National Transcommunications Ltd. was likely to bring forward the transmission of digital TV by several years. Using the acronym SPECTRE (Special Purpose Extra Channels for Terrestrial Radio-communication Enhancements), ITC and NTL engineers have been investigating the feasibility of squeezing a number of low-power digital signals into the gaps in the frequency spectrum between the existing four analogue TV transmissions. Such a scheme would, if practicable, allow enhanced quality digital widescreen transmissions to be introduced gradually, allowing viewers who choose to buy new digital receivers to watch the new services, without affecting existing services in any way.

The key to allowing this to happen is that the new transmissions must be of extremely low power, so that they do not upset the existing programme transmissions - after all, most of the new Channel Three franchise holders have paid tens of millions for the right to broadcast and there would, quite rightly, be ructions if anything were done to disturb their transmissions. Low power analogue TV transmissions would not be suitable for squeezing into the spectral gaps, because they are not very rugged, demanding high signal to noise ratios before satisfactory picture quality can be achieved. If, however, specially processed digital signals are used, together with a cleverly designed modulation system known as OFDM (Orthogonal Frequency Division Multiplexing), the resulting signals can be inserted at low power into the existing gaps in the spectrum, so that they do not interfere with their neighbouring high-powered analogue TV signals and yet they are rugged enough for a digital receiver to be able to decode them into perfect pictures and sound.

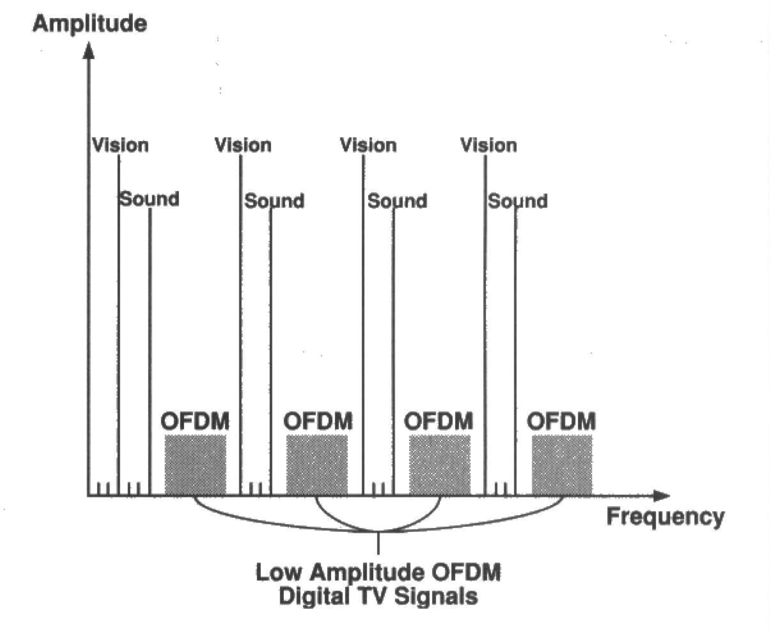


Fig.1 Showing how low power digital signals can be inserted into the gaps in the spectrum between the existing BBC1, BBC2, Channel 3, and Channel 4 transmissions.

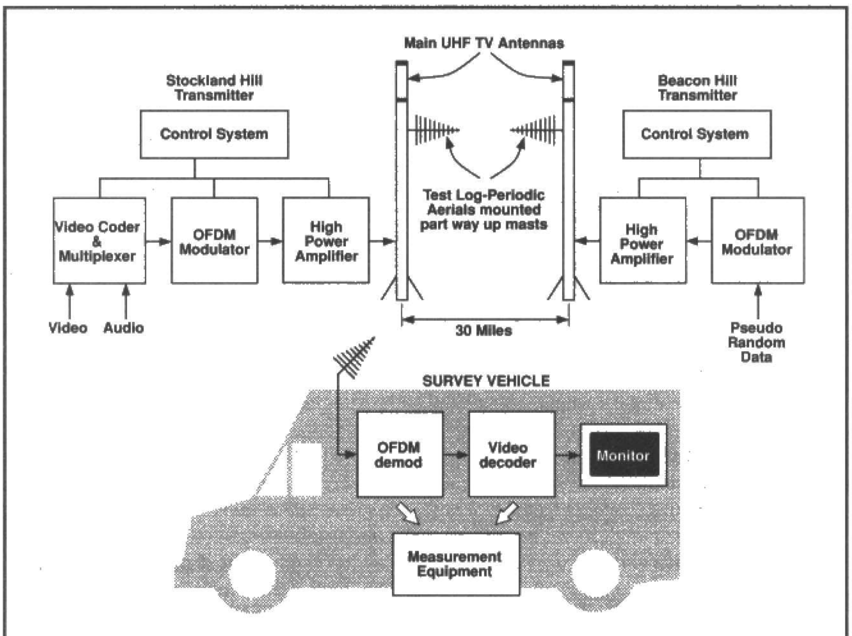


Fig.2 Arrangements for field trials in Devon ITC/NTL IBC 92 paper)

In ETI August 1992, details were given of the arrangements for field trials of the SPECTRE system that have been carried out using the Stockland Hill and Beacon Hill transmitters in Devon. The transmitters are about 30 miles apart, and at each site a log periodic aerial has been erected half way up the existing mast; the aerials are directed at each other, making possible a range of different experiments. Normally one transmitter broadcasts a digital television signal using the OFDM modulation system, and the other radiates an interfering signal.

The arrangement shown in the diagram indicates that Stockland Hill is configured as the provider of the wanted digital signal, and Beacon Hill as the source of potential interference. The Stockland Hill transmission could be a compressed digital video signal modulated using OFDM, whilst the interfering OFDM signal from Beacon Hill is modulated by a pseudo-random data sequence. A mobile field strength measuring vehicle can drive around the service areas, checking on received picture quality and measuring both field strengths and error rates. The

OFDM transmissions take place at the same time as the two stations are transmitting their normal four PAL UHF transmissions. The Stockland Hill transmitter is well sited for tests of the effects of SECAM transmissions from France, and of co-channel interference from the main Rowridge UHF TV transmitter on the Isle of Wight.

625 line widescreen digital signals at 216Mbit/s. The programme material had actually been originated in full HDTV format, and had been downconverted to 625 lines for the demonstration. The programme was a Thames Television production, originally made for the European Commission, called 'The Return of Columbus', which contained a wide range of

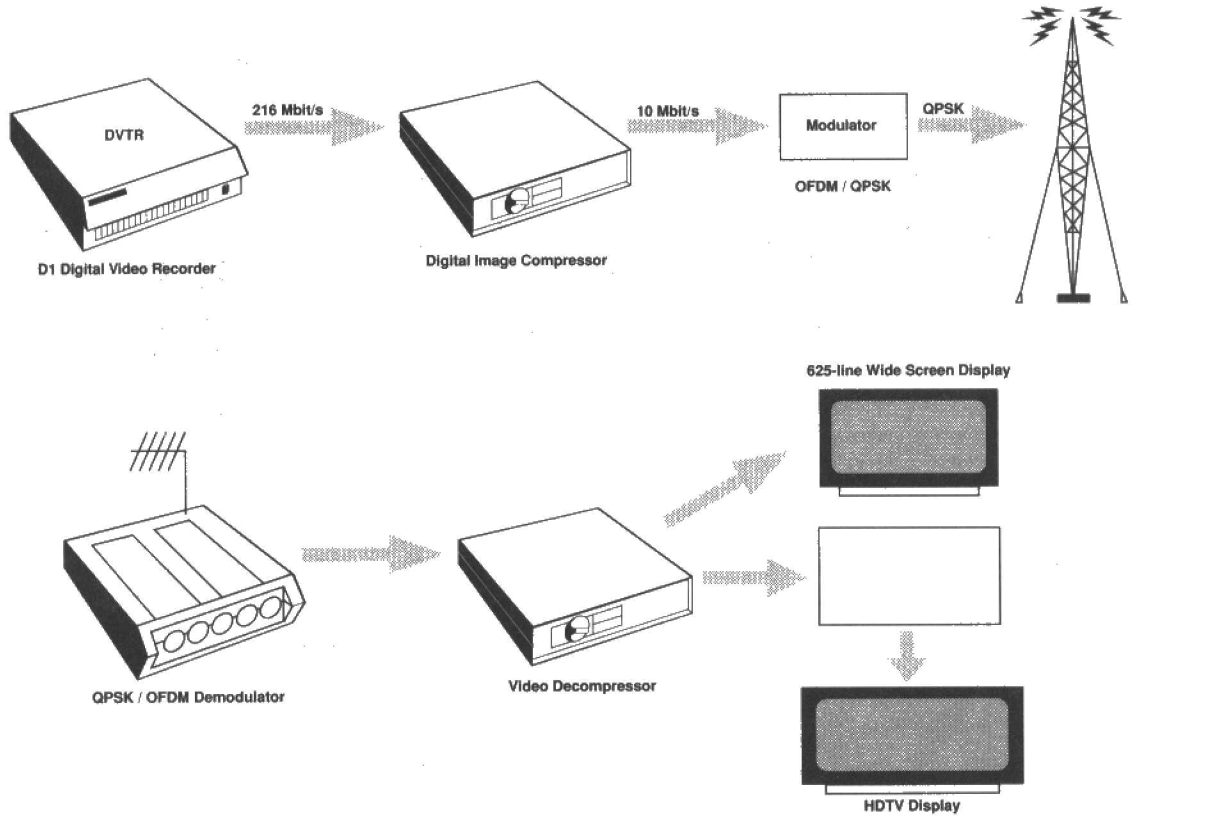


Fig.3. Arrangements for the digital picture transmissions in Devon.

different types of picture material shot under all kinds of lighting conditions, indoors and out. The 216Mbit/s digital picture signals were then digitally compressed into a data stream of about 10Mbit/s, which was then QPSK coded and fed to the OFDM modulator and transmitted on UHF Channel 24 at an effective radiated power of 250 watts, just one thousandth of the power of the accompanying 250 Kilowatt West Country Television analogue transmissions, radiated on Channel 23 from the same site. High quality digital stereo sound signals were also radiated, at a data rate of about 250kbit/s.

The widescreen digital pictures were superb! Two different displays had been provided in the hotel, one a 39" Sony professional HDTV monitor, which showed up-converted 1250 line pseudo-HDTV pictures, the other a domestic widescreen television from Nokia, which provided surprisingly good 625 line results on its 36" diagonal screen. This is the type of receiver that is now starting to appear in UK shops and, if the price can come down a little, could prove very popular; already the rental companies are saying that the demand for such receivers is exceeding their expectations. Although they couldn't ever be called 'compact', such receivers could be fitted into many a domestic lounge without pushing out the rest of the furniture. In contrast, the huge professional HDTV monitor was bigger than many a wardrobe, far too wide to pass through a standard domestic doorway and takes at least four men to lift!

Another interesting facet of the demonstrations was that the ITC showed coverage maps of the Stockland Hill transmitter, which indicated that at the location of the hotel, signals from Stockland Hill were very poor, due to the screened nature of the city-centre location; the hotel normally receives its pictures from the nearby Exeter St.Thomas relay station. In spite of the poor reception conditions, however, the digital signals demonstrated their ruggedness by providing error-free pictures throughout the demonstration.

Co-operation with Europe, and the BBC!

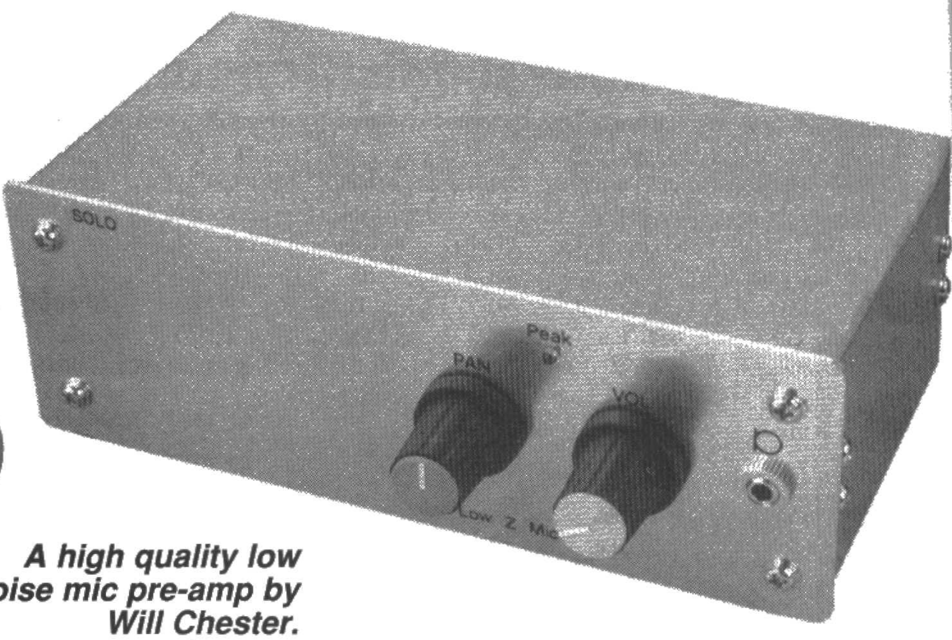
The ITCJNTL digital transmission research work will continue in the forthcoming months, and the results are being fed into the various European committees currently looking at digital broadcasting. The hope is that European broadcasters and governments will be able to develop a common strategy for the implementation of digital television broadcasting - don't I remember something similar being planned for satellite broadcasting? On the co-operation front, it was encouraging to see that the BBC Breakfast Time programme carried a four-minute piece about these very significant demonstrations from Independent Television, and that BBC engineers, who are very much interested in digital transmission developments, and actually carried out a short transmission test of their own, in co-operation with Thomson, earlier in the year, also attended the Exeter demonstrations. ETI will keep you updated, as digital TV research continues.

Test transmissions - pictures at last!

For some months now the test transmissions have been quietly taking place, but the digital transmissions have consisted of streams of pseudo-random data, not of pictures, since the essential work has been to measure the error rates and the types of error on the received signals throughout the coverage area of the transmitter. At the end of January, for the very first time, arrangements were made to transmit digital pictures from the Stockland Hill transmitter, and, using a standard 'group A' television aerial on the top of a hotel close to the railway station in the middle of Exeter, these signals were received, decoded, and displayed on two widescreen receivers.

A D1 component digital videotape recorder had been installed at the transmitter site, providing

The Solo Mic Pre-Amp



A high quality low noise mic pre-amp by Will Chester.

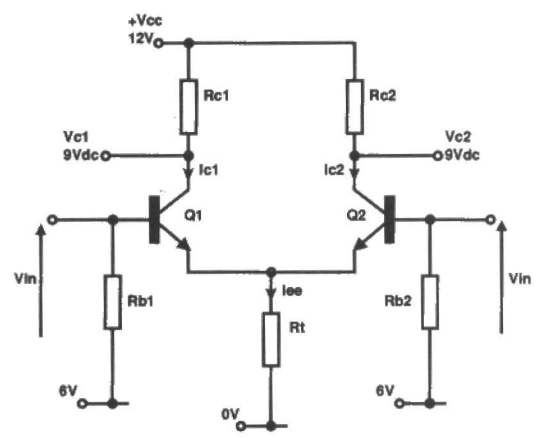


Fig.1 The differential stage

This mini-project represents a back-to-basics approach to the design of a high quality, low noise microphone amplifier.

The amplifier is intended for use with microphones in the impedance range of 200 to 600R having sensitivity figures in the range -80 to -74dBV (100 to 200µV).

Both quality and low noise performance is achieved through the use of a minimum number of active components and careful selection of the DC design parameters. The simplicity of the circuit encourages experimentation and demonstrates some useful, if not important design techniques.

The heart of this amplifier is a differential input stage. This has the ability of amplifying only 'difference' signals between it's input terminals. In other words, any signals that rise and fall simultaneously (in phase) at both the input terminals are amplified only by a very small fraction of the difference signal gain. In fact, for all intents and purposes, these in-phase or common mode signals are totally rejected compared to the differential, normal mode signal. An example of unwanted common mode signal, or noise is 50Hz mains 'hum' induced into amplifier input leads. Higher frequency noise can also be induced into sensitive audio circuits by nearby logic devices switching with fast rise and fall edges, as is the case with microprocessor equipment.

The differential input stage formed around Q1 and Q2 is the basis of all op-amp circuits.

Many operational amplifier chips are now available, each type offering improved performance in some parameter or application. It seems a shame that these integrated circuits, using tens if not hundreds of transistors are often used as the black-box chip without a second thought to their fundamental design.

The circuit presented shows that it is possible to construct a high performance audio pre-amplifier using only five transistors.

A master volume is provided and this is accompanied by a pan control so that the mono output can be placed anywhere within a stereo output image. Additionally a peak-level indicator is built around a low power comparator.

The Differential Stage

Figure 1 shows the basic idea of the input stage.

Transistors Q1 and Q2 are biased from the base resistors RB1, RB2 which are connected to the mid-way point of the power supply voltage.

The base current drawn by each transistor will be extremely small, giving an almost negligible voltage drop across each base resistor. If the transistors are perfectly 'matched' this small standing DC voltage at the bases will be

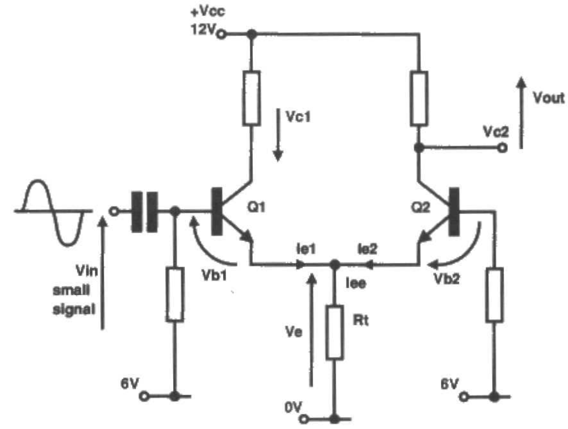


Fig.2 Small signal operation

PROJECT

identical. In practical op-amps there is usually a small difference, known as the input offset voltage.

Now, the base terminals are both at the same potential (well, within a few millivolts), at mid supply voltage in this case. This voltage is arbitrarily called 'earth' in op-amp circuits and thus the inputs are said to be at "virtual earth". Yes, yet another fancy term thrown around by engineers! The operating current for both transistors is set by Rt. This resistor, often referred to as the "long tail", carries the DC operating current for Q1 and Q2. These currents will be equal if we use matched transistors, therefore:-

$$I_{EE} = I_C \text{ (total)} = I_{C1} + I_{C2}$$

The current in Rt will only be very slightly greater than Ic (total) due to I_B being very small (as is the case for a high current gain, h_{FE} say > 200). We can say that this total operating current is determined by the value of Rt and the voltage across it, in other words:-

$$I_C \text{ (total)} = [(Vcc/2)-V_b]/Rt$$

Where V_b = 0.6 volts; the voltage dropped across the base-emitter junction.

For the microphone amplifier this operating, or quiescent, current is chosen so as to minimise noise generated within the transistors themselves.

The collector resistors R_{C1}, R_{C2} form the load resistors for each transistor, the output voltage being taken from between the collectors.

The value of Rc is chosen so that the DC quiescent current gives a DC output of (0.75 x Vcc) at each collector. This setting maximises the available swing (positive and negative half-cycles) for the amplified output voltage.

$$Rc = (Vcc - 0.75Vcc)/Ic$$

where $Rc = R_{C1} = R_{C2}$
and $Ic = I_{C1} = I_{C2}$

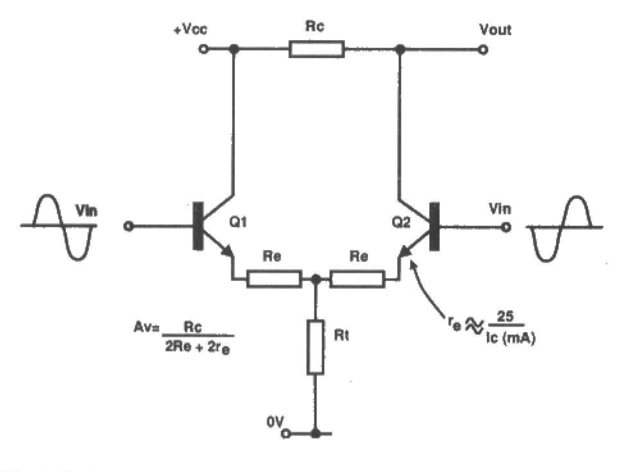


Fig.3 Fixing the gain

Now lets look at what happens when an AC signal is presented at say, Q1 base terminal.

Firstly, the signal should be coupled by a capacitor or transformer so as not to disturb the dc operating point just set at the base.

Figure 2 helps to show what happens.

The following discussion refers to small signal quantities which add to the standing DC currents and voltages.

On the rising (positive) half cycle of signal Vin, the base voltage V_{b1} of Q1 increases causing Q1 collector current to increase. This causes the voltage VE across Rt to increase which reduces the base to emitter voltage of Q2. The collector current of Q2 now falls and this is accompanied by a corresponding rise in voltage V_{C2} seen at it's collector output. On the falling (negative) half cycle of Vin, voltage V_{b1} is reduced causing Q1 collector current to fall. This reduces the voltage drop VE across Rt effectively increasing the base to emitter junction voltage of Q2. This gives a rise in Q2 collector current and therefore a fall in output voltage VC2.

Consideration of what has just been said will show that, with the output taken from Q2 collector, Q1 base constitutes a non-inverting input. If the input was instead coupled to Q2 base, the output would be inverted.

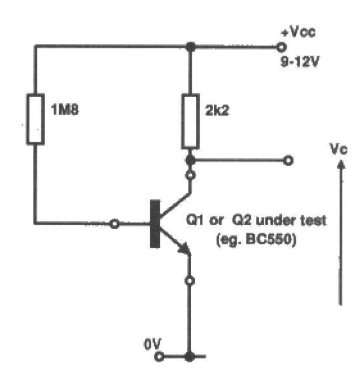


Fig.4 Finding a matched pair

Common Mode Performance

The characteristics of Q1 and Q2 are well matched, especially in terms of current gain.

When operated in true differential mode, the input is put between the two base terminals, such that as the signal rises at Q1 base the signal is falling at Q2 base. The output is taken from between the collector terminals.

The total current flowing in Rt is always the same since a rise in one transistors collector current is matched by an equal and opposite, that is fall, of collector current in the other transistor. This means that voltage V_E, across Rt will remain fixed. The emitter current I_{E1} and I_{E2} will vary unimpeded by Rt. What happens if the same input, Vin is coupled to both base terminals at the same time (in other words, a common mode signal)?

This would mean that as emitter current I_{E1} increases emitter current I_{E2} will also be increasing. Both currents are trying to turn off the opposite transistor!

What actually happens is that each current flowing in Rt causes the voltage V_E to increase. The outcome is that both collector output voltages will change by an equal amount giving rise to no difference between them. This results in very little output for common-mode signals. The greater the mismatch between Q1 and Q2, the greater will be the output voltage for a common-mode input.

Matched pairs and arrays of transistors are widely available on so called monolithic chips.

For instance the 8-pin SSM2210 device has two transistors sharing the same substrate. This enhances the thermal stability while the transistors themselves are matched with their gains within 0.5%.

Practical Gain

To allow determination of differential gain, a small emitter resistor R_E is used as shown in Figure 3.

For differential-mode signals the gain, Av is given by:-

$$Av = Rc/(2R_E + 2re)$$

where re is the intrinsic emitter resistance, given approximately by:-

$$re = 25/Ic \text{ ohms.}$$

Where Ic is in mA

For common-mode signals the gain AVCM is given by:-

$$AVCM = Rc/2RT$$

From this last equation it can be seen that the larger Rt value is, the better, since this will reduce the common mode gain but leave the differential gain unaffected.

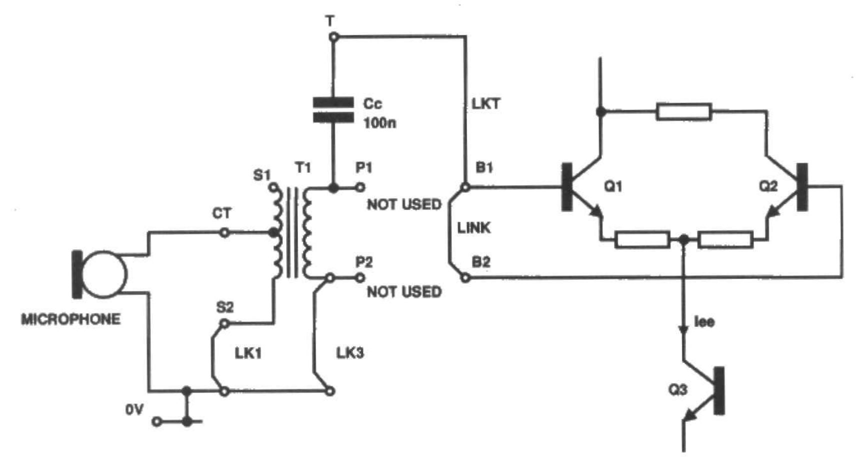


Fig.5 Common mode input arrangement

The circuit of the microphone amplifier employs a constant current source based around Q3, see Figure 6. This maintains the total emitter current (and thereby collector current) constant and will not allow common mode signals to increase this current. Because of this reluctance to change, current sources have a very high impedance. Replace Rt with a current source and wave goodbye to common-mode nasties!

Note that one collector resistor can be omitted to allow the differential output to be sensed across the remaining load resistor. Omitting one collector resistor does not affect the total emitter current since this is set by the current source, and both transistors are matched.

Rattle and Hum

It is perhaps useful to add some notes regarding noise, of the extraneous type that is.

The circuit of the microphone amplifier is shown in Figure 6. Since transformer T1 is composed of windings, any nearby magnetic fields (50Hz) will induce alternating currents in T1. The 'noise' voltage produced will appear between Q1 and Q2 base terminals as a normal differential 'signal'. This is of course most undesirable!

Some attempt should be made to shield or screen T1 completely but this is not particularly easy for magnetic fields at low frequency. It may well be more feasible to simply distance any interference source (such as a power transformer) away from the microphone transformer, T1.

The high impedance that current source Q3 provides gives the input stage an extremely good common-mode rejection performance, providing Q1 and Q2 are well matched (small signal gains, h_{fe} to within 5% of each other).

If, for instance long leads are used from T1 output (primary), any noise induced or picked-up along their length will appear separately but in-phase at Q1 and Q2 base terminals.

Now, the current source does not permit both emitter currents to change in the same direction. To put it another way, equal changes in transistor output voltage (both collectors positive or both negative) do not give any net change or difference across the collector load resistor. So when using matched devices, the output is more or less nothing for nasty common mode noise!

However, it is a good idea to keep T1 (primary) leads close to each other. Moreover, twisting this pair together will make common mode pick-up even more difficult. The closeness of the wires effectively reduces a relatively large pick-up loop to a series of much smaller pick-up loops. Any magnetic fields induced into the successive 'loops' cancel out. It goes without saying that the microphone lead is also screened. The printed circuit board has been designed so that there are no closed loops within the zero supply line : the aim again being to eliminate induction loops. The cable screens are terminated at one end only for the same reason.

Testing And Setting Up

Before applying the battery voltage to the circuit, first check that there are no obvious short circuits. Do this by applying an ohmmeter across C1. Any reading lower than 2kohms should be treated with suspicion. If all is well, connect the battery and perform the following checks with a multimeter set to measure DC voltage. The microphone does not need to be connected as we are only looking at static or quiescent conditions.

1. Base of Q1 (SSM2210 pin 2) ... should be 4.5V approximately.
2. Base of Q2 (SSM2210 pin 7) ... should be 4.5V approx.
3. Base of Q4 ... should be approx. 2V.
4. Base of Q5 ... should be approx. 6.1V.
5. Pin 3 of IC1 ... should be 8.1 V.

Place the multimeter probes between zero and C2 positive side (or Q2 collector) and adjust preset PR1 until the DC voltage reads 6.75V. This has now set static operating current, IEE to 250µA.

IC1 pin 2 should be about 5.5V and LED 1 will be off.

Check the operation of comparator IC1 by momentarily shorting Q5 collector and emitter terminals. LED 1 should be on for the duration of the short circuit. If it does not light, check that the link is fitted in R22 position and that LED 1 is fitted the right way round.

A residual voltage of about 0.1 volts will be present across R19. this is quite normal and Q6 will remain off since it's base to emitter voltage is significantly less than 0.6 volts.

The mic. amp. is now ready to go, as they say.

If you are inquisitively inclined and prone to bursts of

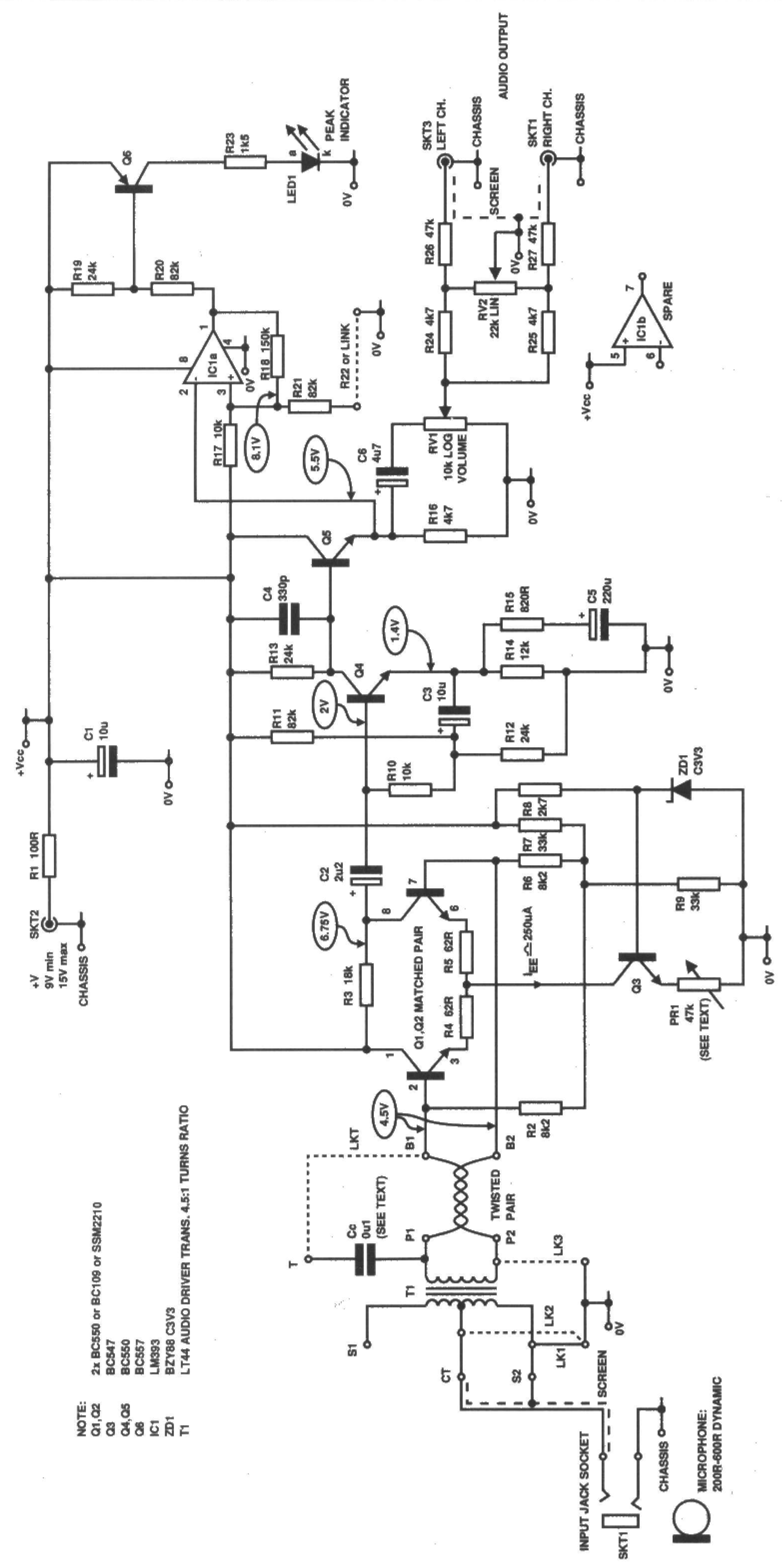


Fig.6 The differential microphone amplifier

HOW IT WORKS

The dynamic microphone is matched to the differential input stage by transformer T1. This is an LT44, more usually adopted for interstage coupling between amplifier stages. The secondary winding impedance is 1.2k and the centre-tap provides a relatively good point at which to input the microphone. The voltage step-up ratio is about 1:9 from centre-tap to primary winding.

The LT44 is in fact a design compromise since types purposely available for microphone matching are some eight times more costly.

Transistors Q1, Q2 work together as the matched-pair of the differential stage. The quiescent collector current in each device is set low (125µA) in order to give good internal noise performance for source impedances in the range 1k to 35k.

Base bias resistors R7, R9 set the matched pair bases at half supply (4.5V for a 9V supply) and they provide enough current to ensure the transistors operate comfortably in the linear region.

T1, primary winding floats at the bias voltage of Vcc/2 and no DC current should flow in it. Resistors R2 and R6, as well as feeding bias current to each transistor, also set the total differential input impedance to around 16k thereby matching to the input through T1.

The constant voltage across PR1, derived from zener ZD1, is used to set up a constant quiescent DC current in the long- tail of the matched pair Q1, Q2. The quiescent current is set when Q2 collector voltage is 6.75V DC.

The differential stage has a voltage gain of about 34. The signal output is sensed across R3, Capacitor C2 couples the signal to common emitter stage Q4 while blocking the DC voltage.

Capacitor C3 'bootstraps' bias resistor R10 so that its value, to AC signals, appears much higher than 10k. Without C3 resistors R10 and R12 will be in parallel with R3 and thus reduce the input stage gain.

The gain of Q4 stage is set at 23 with R15 equal to 820 ohms. Capacitor C4, in parallel with load R13 ensures that any signals above 20kHz and at radio frequency are greatly attenuated.

Emitter-follower stage Q5 by virtue of it's very high input impedance ensures that the load, volume control RV1 does not affect the gain stability of Q4.

The output, typically 1.4 volts RMS at full volume is fed to a pan network. This will attenuate the output to around 1V RMS with RV2 wiper at midway or opposite end (ie. other channel at zero output).

A peak voltage detector is built around IC1. This is designed to flicker LED 1 when the output level is in danger of being clipped (for instance due to overdrive at the input). The values of R17 and R21 shown set the threshold at 90% of Vcc (8.1V) so that LED 1 will not come on unless the output at Q5 emitter exceeds 1.8V RMS (2.5V peak + 5.5Vdc = 8V).

Resistor R18 helps to speed up peak detection but is primarily used to lower the threshold to 84% of Vcc when the output of IC1 goes low. The lower threshold gives an hysteresis effect which keeps LED 1 on long enough so it can be readily seen for quick peak deviations.

Components R1 and C1 filter the DC supply line, important if the pre-amp is fed from a 240V AC mains powered supply.

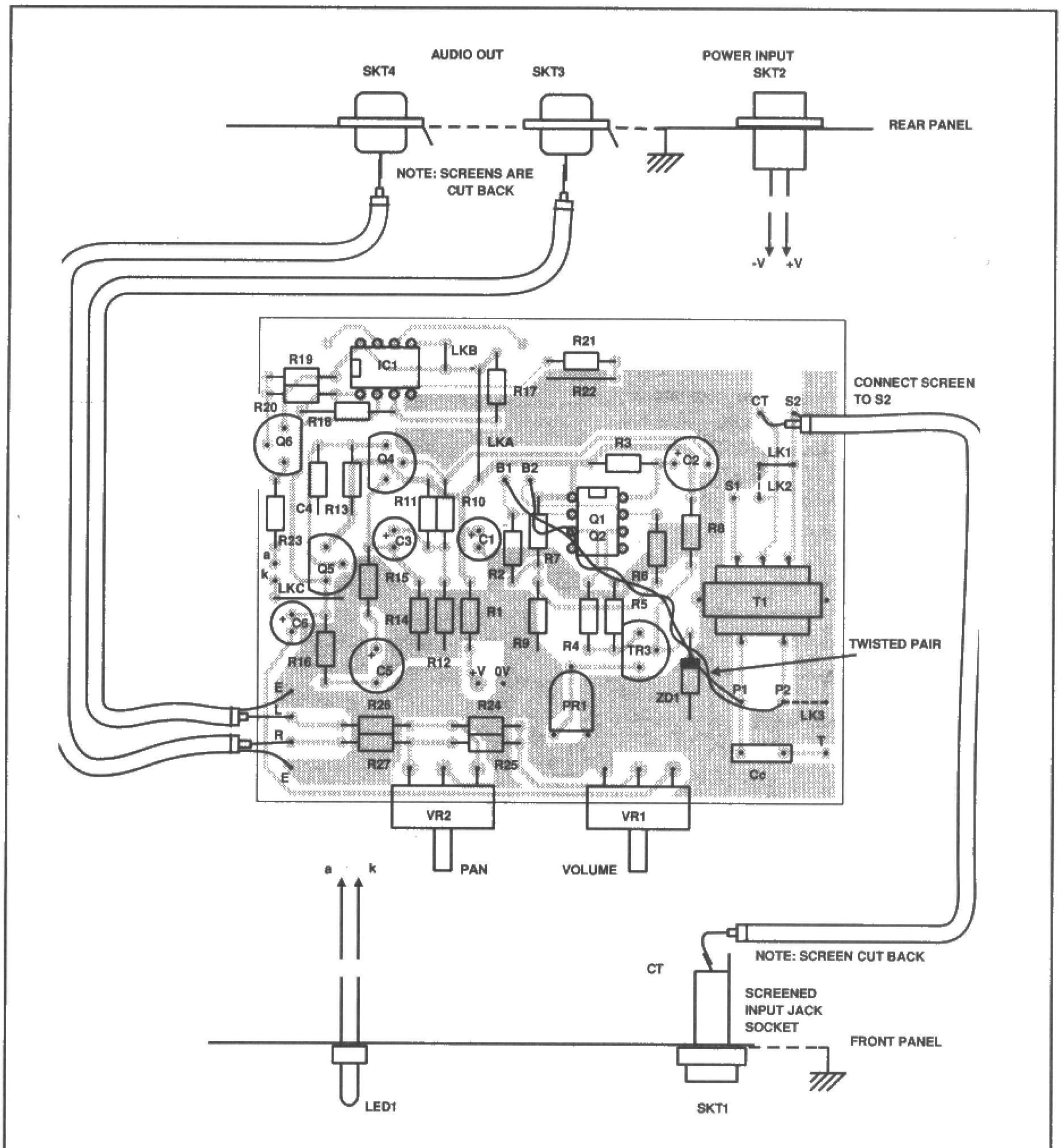


Fig.7 Solo mic pre-amp component overlay

experimentation there are two areas in which to engage yourself, read on!

Matching the Pair

If the cost of SSM2210 monolithic pair seems prohibitive, try selecting two transistors out of your own stock. BC109 or BC550 would be preferable to maintain low noise in the amplifier.

The trick is to find two that show similar gain characteristics. This can be gauged to some degree by using a simple circuit such as that of Figure 4. We shall use this to look at the static or dc gain characteristic although for our amplifier it is the small signal or AC gain that is to be matched. The DC performance is just as relevant as long as we compare two devices of the same type number.

Follow this procedure. Alternately substitute transistors of the same type into the circuit of Figure 4. Each time, note the DC voltage at the collector. While taking the reading do not keep your fingers on the transistor case - the temperature will cause the collector current to increase and give a misleading low output voltage. After inserting each transistor take the voltage reading after about 10 seconds, just to let the voltage settle down.

Be sure to put an identifying mark on each transistor so that each one can be related to a voltage on your list.

Now look at your voltage list and aim to find two readings that are within 50 to 100 millivolts of one another. If possible identify two transistors that give readings within 50mV. You may well need to test a great number of devices to get this close! This is why I suggest to go no further than looking at your existing stock of devices.

Assessing Common Mode Rejection

The common mode performance can be assessed subjectively by using the input arrangement of Figure 5.

Connect one of the outputs L or R to a power amplifier and set the volume levels of both amps at a moderate level with the pan control at middle setting.

Capacitor Cc is necessary to prevent the grounded output winding of T1 from disturbing the DC bias at the transistor base terminals.

The signal input appearing at both transistors will be in-phase and current source Q3 will not allow both emitter currents to vary in the same direction as each other. The total current, IEE always equals 250 micro-amps.

Very well matched transistors for the differential pair will ensure that the final output is inaudible.

Transistors selected using Figure 4 will give some audible output, even with the current source Q3 present. This is due to the mis-match.

However, by experiment you can compare common mode output with differential output and you will indeed find that the differential performance is superior.

In the technical data for operational amplifier chips, common mode performance is expressed in terms of the ratio called common-mode-rejection ratio. This is simply the differential gain divided by the common-mode gain and then expressed in decibels:-

CMRR = 20.log (Av/Avcm) db

With reference to the components in Figure 3 the rejection ratio is given by:-

CMRR = 20.log [Rt/(R_E+re)] db

You can see from this that the greater Rt value, the greater is the common mode rejection.

Construction

Refer to the component overlay shown in Figure 7.

Begin assembly by inserting and soldering all the fixed metal film resistors. Solder in place links LK1, LKA, LKB, LKC and R22. Next insert and solder the preset PR1, then capacitor C4 next to R13.

Position transformer T1 so that the fixing tabs go through the two holes provided on the PCB. Bend the tabs under the board and solder them to the copper foil.

Trim then solder each primary and secondary winding terminal. Apply heat only for the minimum time needed.

Take a 125mm length of connecting wire and cut it in half. Trim the insulation from the four ends then moderately twist the two lengths together. Solder in place between PCB terminals P1, P2 and B1, B2.

Insert all the electrolytics, ensuring that their polarity is correct.

As a quick check, all the negative (black) markings of these capacitors should be pointing down toward preset PR1, except for capacitor C2 whose neg. terminal is adjacent to LK1.

Insert zener ZD1 with the band marking (cathode) to the junction of R8 and Q3 base. Insert the three transistors Q3, Q4 and Q5. The flat side of each should face left when viewing the PCB with PR1 at the bottom.

Insert Q6 so that it's flat side is facing in the opposite direction to the others. Now solder these semiconductors in place, taking care not to apply heat for any excessive time to avoid damaging them.

Solder in place the 8-pin DIL socket for Q1, Q2.

There are two options for Q1, Q2. Firstly, two discrete devices can be used - selected according to the matching procedure given in the test section. Secondly, if experimentation is not desirable and to give optimum performance, the SSM2210 monolithic NPN transistor chip can be inserted.

The 8-pin socket allows discrete transistors to be easily changed since Q1 uses pins 1, 2 and 3 whereas Q2 uses pins 6, 7 and 8.

Solder IC1 in place, being careful to see that it is correctly orientated.

Capacitor Cc is not needed for normal operation but will allow assessment of the amplifier common - mode rejection performance as detailed in the test section.

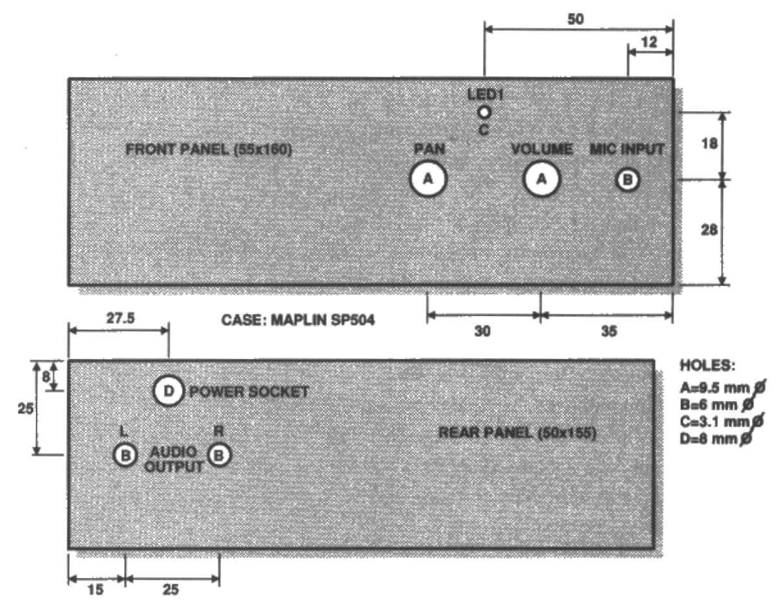


Fig.8 Drilling details of case

Connect two wires to the PCB terminals a and k. Solder LED 1 to the other end, paying attention to correct polarity. The lead next to the 'flat' on the LED body is usually the cathode, k lead.

Cut two lengths of screened single core cable, each 130mm long. Solder one end of each to the PCB terminal L and R. Solder the screens to the two adjacent E terminals.

Connect an 80mm length of screened cable to PCB terminal CT and S2, the screen going to S2. To the other end solder the tip connection of the 3.5mm jack socket. Neatly cut back the screen to the sheath of the screened cable.

For the power supply, take two wires from the +V and 0V PCB terminals and connect them to the tags on the power jack socket. Solder the +V wire to the pin connection on the power socket. When the power plug is connected, 0V will be connected to the case metalwork (chassis).

Position and solder potentiometers RV1 and RV2.

Now turning to the case. The one used in the prototype has steel top, bottom and back panels. The front panel is made of aluminium. When fully assembled any one panel can be removed to allow access.

Drill holes in the front panel and rear panel according to the drilling detail diagram, Figure 8.

The hole for LED 1 is carefully made so that the LED will snugly push-fit. Assemble the case fully, then remove the front and top panels. Fix the two phono sockets to the 6mm diameter holes in the rear panel. Fit the PCB by bolting the

pan and volume potentiometers to the front panel. Use additional nuts or washers as spacers behind the panel. Fix the microphone jack socket to the front panel. Push LED 1 into hole C. Refit the front panel to the case.

Now connect the core of each screened output lead, L and R, to the rear panel phono sockets. Again refer to Figure 7 and note that the screens of each cable are cut back.

The 0 volt connection to input and output sockets relies on metal to metal contact on the case panels. This is done to cut down earth loops, that can also masquerade as antennae, (see the section 'Rattle and Hum').

Finally fit the power socket to the rear panel.

Leave the top panel off and proceed to perform the checks detailed under 'setting-up'.

In Use

Although the original design was for use with a dynamic microphone, the pre-amp may also be used for other low level signals. Note that this design does not include any frequency response shaping. This is usual since most microphones have a very nearly 'flat' characteristic.

The maximum input that can be handled is 3mV (into 200R), before the gain of the differential stage has to be reduced to prevent clipping.

However, at 3mV the gain of Q4 stage should be reduced to its minimum of 2.0 by removing R15 completely. This action will keep the final signal output across R16 to less than 2.6V peak. The positive excursion at this level, when added to the 5.5V DC at Q5 emitter, will tend to flicker LED 1. This indicates that further increases of input level may give a clipped output.

For gains above 2, R15 is adjusted according to the equation.

$$A_V = R13 / (R15 + re)$$

where re is approximately equal to 210R.

This is OK so long as R15 value is less than 10% of R14 value, otherwise the parallel combination must be included in the calculation:

Therefore $A_V = R13 / (R14 // R15) + re$

(for R15 greater than 1k2)

Resistor R15 is changed to alter gain since a change to R13 or R14 will upset the DC conditions. When changing R15 be sure that the reactance of C5 is low by comparison, at the lowest signal frequency of interest. As a good rule of thumb ensure that:

$$C5 = 10 / (2pf_L R15) \text{ Farads}$$

where f_L equals 50Hz, for example.

If the input is put between terminal S1 and S2, a maximum input of 6mV (into 800R) can be tolerated if R15 is removed.

The minimum recommended supply voltage is 9V. This has been specified to set up the circuit for convenience only. It is preferable to use a supply of 12 to 15 volts since this will give greater 'headroom' around the output signal peaks. At 9 volts, a little more care in the use of the microphone, is needed to avoid clipping.

Using a PP3 type battery, current drain is typically 4.8 mA so the battery should last some considerable time. The power plug and socket is used in place of an on/off switch for simplicity.

The project is built into a metal case and adequate space has been left to allow the inclusion of another circuit. If, for instance a guitar pick-up pre-amp is incorporated, the complete unit would prove appealing to any budding singer/ musician.

The output can be taken to the input of a tape deck or to the spare input of a stereo audio mixer where inadequate provision is made for lower level inputs.

PARTS LIST

RESISTORS - METAL FILM +/-2% 0.25w UNLESS STATED OTHERWISE.

R1	100R
R2,6	8k2 1%
R3	18k
R4,5	62R 1%
R7,9	33k
R8	2k7
R10,17	10k
R11,21,20	82k
R12,13,19	24k
R14	12k
R15	820R
R16,24,25	4k7
R18	150k
R22	0R (link)
R23	1k5
R26,27	47k
PR1	47k lin MINIATURE PRESET POT
RV1	10k log VARIABLE RES
RV2	22k lin VARIABLE RES

CAPACITORS

C1,2	10µ 16V Electrolytic
C2	2µ2 16V Electrolytic can.
C4	330p ceramic or polystrene
C5	220µ 16V Electrolytic can.
C6	4µ7 16V Electrolytic can.
Cc (optional)	100n polyester.

TRANSFORMER

T1	LT44 Miniature audio transformer, Turns ratio 4.5:1. Primary impedance 20k, secondary 1k (centre tapped)

SEMICONDUCTORS

ZD1	BZY88C3V3 ZENER DIODE 500mW, 3V3.
LED 1	3mm red LED.
Q1,2	SSM2210P DUAL MATCHED NPN TRANSISTORS (8-pin package)
Q3	BC547
Q4,5	BC109C OR BC550
Q6	BC557

MISCELLANEOUS

Input socket 3.5mm panel mounting screened jack.
2 Output phono sockets panel mntg.
Power connecting plug and socket 2.5mm panel mntg.
Connecting wire and screened cable (single core).
PCB
PP3 Battery clip
2 Control knobs
CASE.
METAL CASE type SP504 (Maplin Ltd,)

BUYLINES

All the parts and components are readily available.

Maplin Electronics Ltd. stock the SSM2210 monolithic pair and the SP504 metal case (supplied in flat pack form).

All About... Liquid Crystals

by Douglas Clarkson

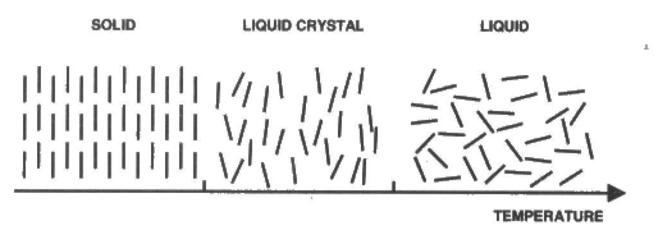


Fig.1 Indication of the solid, liquid crsytal and liquid phases where in the solid phase molecules are fixed relative to each other with high level of organisation, in the liquid crystal phase molecules are more loosely associated but still have some collective structure and in the liquid phase the molecules are free to wander around the liquid with no level of order between the molecules.

Most individuals will be familiar with the concepts of solid, liquid and gas states of matter. There are, a broad range of types of liquid molecules which demonstrate properties intermediate between a 'solid' and a 'liquid'. This is because elements of their structure allow alignments between groups of molecules. Such liquids are called 'liquid crystals'. The liquid crystals which have been used for conventional liquid crystal displays are but a small subset of a much larger family of substances showing such properties. The 'goo' of soap in a wet soap dish is an example of a liquid crystal.

Liquid Crystal Structures

The typical molecule demonstrating liquid crystal effects can be represented as a 'stick' - suggesting an elongated structure. Figure 1 shows this 'between state' of liquid crystals. In the solid, the structure is rigid and fixed. In the true liquid there is complete randomness of direction of the 'stick' molecules. In the liquid crystal there is a general preferred direction of alignment of the molecules. This may be caused by local attachment of molecules to surface structures or it may be caused by local values of both magnetic and electric fields. The direction in which the molecules tend to align is called the 'director'. In some liquid crystals this direction spirals throughout the liquid - giving rise in the process to characteristic optical properties.

Where specific liquid crystal molecules are held in a specific alignment direction, the degree of alignment can be described by means of an order parameter. Where a typical molecule at any one time makes an angle A with the director, the degree of alignment can be described by:-

$$OP = \frac{2}{(3 \cos A - 1)/2}$$

where OP is the order parameter.

Figure 2 shows how this order parameter value falls with increasing temperature until the liquid crystal properties cease altogether. Thus liquid crystals must have a range of operational temperatures which correspond to those likely to be encountered in applications using them. Uptake of energy is associated with the transition of the liquid crystal to its liquid state. This energy is typically much smaller than the phase transition of solid to liquid crystal or liquid crystal to liquid.

The term 'nematic' (threadlike) liquid crystal is typically applied to liquid crystals with elongated molecules. In some nematic liquid crystals the direction of the 'director' twists within the liquid. This is termed a chiral nematic liquid crystal. The 'pitch' is the distance over which a cycle of alignment of the director is repeated.

Where nematic liquid crystals align themselves into strata like structures as shown in figure 3, smectic phases are created. The 'a' phase is introduced when the director of the individual molecules is perpendicular to the layered direction and the 'c' phase when the alignment is not chiefly perpendicular. In all a total of 11 such phases have been identified. Researchers in India have recently discovered that 'disc' like molecules can also demonstrate liquid crystal properties. Where the disks behave individually like 'nematic' or stick like molecules the phase is termed nematic discotic liquid crystal phase. Where the molecules clump together to form columns, the phase is termed columnar discotic phase.

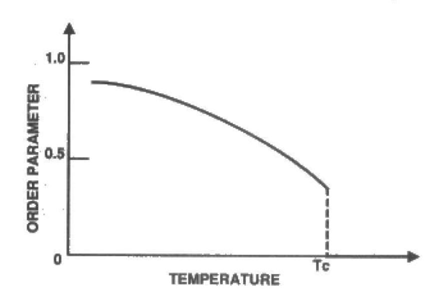


Fig.2 With increasing temperature within the liquid crystal phase the degree of orderliness decreases until it vanishes at the transition temperature to the liquid phase.

Liquid crystal polymers have also recently been discovered and there is considerable interest in developing applications using them.

First Discoveries

In 1888 the Austrian botanist Friedrich Reinitzer identified an organic substance with strange properties. It melted

at 145.5 C to form a cloudy liquid which became clear at 178.5 C. Reinitzer in turn passed the sample of what was in fact cholesteryl benzoate to the German physicist Otto Lehmann who had developed techniques for observing the optical properties of substances (such as polarisation) as a function of temperature.

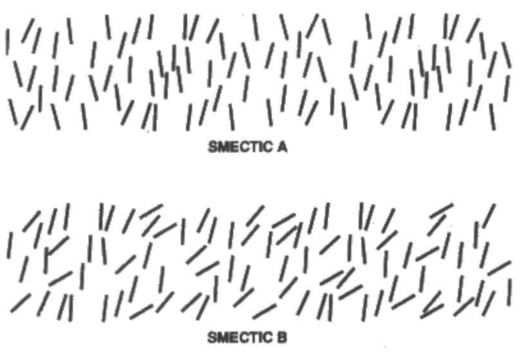


Fig.3 Smectic liquid crsytal phases occur when the liquid crsytals order themselves into layered structures as shown. Phases A and C are shown although up to eleven phases have been identified.

Lehmann in turn was able to identify the properties as arising from different phases of the liquid with differing degrees of 'order' in the arrangement of the molecules. It was Lehmann who eventually coined the term of 'liquid crystal'.

Interest in liquid crystals was very much one of 'pure' science up until the mid 1960's. This was the process of understanding mechanisms and predicting properties of such substances. The great acceleration in interest came in 1968 when two researchers at RCA showed how an electric field could switch a liquid crystal from cloudy to clear. This led to major programmes of R&D to dramatically reduce the power required to drive such displays. The level of basic R&D continues at a high level.

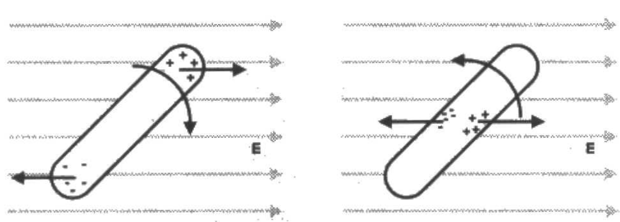


Fig.4 Liquid crystal molecules can exhibit either a permament dipole as ahown in a) or an induced dipole as shown in b) when placed in an electric field. In the case of the permament dipole the molecule will tend to be aligned in the direction parallel to the field and in the case of the induced dipole at right angles to the field.

Interaction of Electric & Magnetic Fields

It is the interaction of liquid crystals with electric fields which is used in the majority of liquid crystal display applications. Liquid crystals exhibit two major modes of behaviour in an electric field as shown in figure 4. Where the molecule behaves like an electric dipole due to the distribution of charge within the electron clouds of the molecule, the positively charged end will tend to be attracted in the positive field direction and the opposite end in the opposite direction - tending to twist the molecule so that it becomes aligned in the direction of the electric field vector. Where the molecule does not exhibit such behaviour, the electric field can induce a charge distribution across the molecule which tends to align the molecule at right angles to the field direction. Such induced dipoles tend to be weaker than permanent electric dipoles.

Where liquid crystal molecules behave as magnetic dipoles, they are also influenced by the presence of a magnetic field. It is predominantly the interaction of electric fields which are used for current LCD technology.

Field Interactions

Liquid crystal molecules are strongly influenced by the surfaces with which they contact. If a glass surface is rubbed by a piece of cloth the liquid crystal molecules will tend to align in the direction in which the surface was rubbed. If a thin film is sandwiched between two such plates the liquid

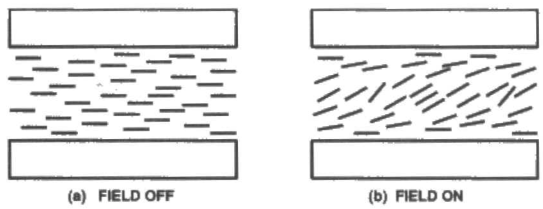


Fig.5 Initially in a) with the electric field OFF the molecules align parallel with the glass plates. When the field is switched ON at a sufficiently high value the orientation of the molecules changes to try to align with the field.

crystal molecules will tend to align up as shown in figure 5. If a field is gradually applied which tends to align the molecules at right angles to their initial positions, then there is a specific level of field at which the molecules will try to switch round to the new orientation. The molecules near the centre of the film will be more free to move than those close to the glass surfaces. This transition is called the Freedericksz transition and is characteristic of the mode of behaviour of liquid crystals.

If the glass surfaces are treated differently so that the molecules lie as in figure 6 then, with the application of a threshold value of field, the transition indicated will take place. For thicker films where the molecules in the centre are more free to twist, smaller values of switching field are observed. Typical switching field values for a 25 micron thick film would be 400V/cm - corresponding to an applied voltage of 1 volt.

Interaction with Light

It is the varied polarisation characteristics of light passing through liquid crytals which is used to produce display effects. Ambient light can be considered to consist of light of undefined polarisation. A simple polariser will transmit light of a given polarisation - a maximum of a half of the incident light. Where two polarisers are used in parallel, ie the axis of polarisation of the secons is the same as that of the first, then light will be transmitted. Where the axes are 90° different, the polarisers are 'crossed' and very little light if any will be transmitted.

In chiral nematic liquid crystals use is made of the effect of rotation of the axis of polarisation. Typically the angle is moved through either 90 or 270°. This effect can be considered to take place by the difference in the speed of travel of light in directions 90 degrees apart.

Liquid Crystal Displays

A range of technical terms are used to describe the properties of liquid crystal displays. One of the most basic of these is threshold characteristic as shown in figure 7 where V90 and V10 refer to voltage levels corresponding to 90% and 10 % relative brightness. For displays which require only 'on/off' function, there is an advantage in ensuring the V90 - V10 is as small as possible. Where displays are required with several levels of brightness, control of such displays is made easier by having a more gentle change of brightness with voltage.

Another important characteristic is the turn-on and turn off behaviour. Figure 8 shows how Ton (time to switch on) and Toff (time to switch off) are defined. Ton is defined as the time between the application of the signal and 90% of the final brightness. Toff is defined as the time taken from switch off to derive 10% brightness. Where Blow and Bhigh are the brightness values of the two states of the display, the contrast of the display is defined as the ratio of Bhigh/Blow. Values range typically from 10 to 50.

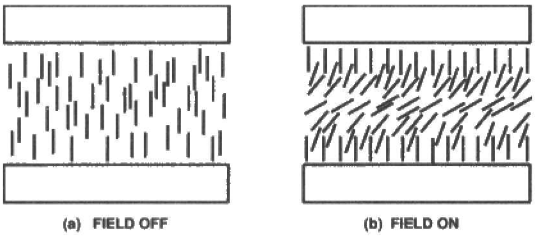


Fig.6 Where the molecules are aligned in a different direction as indicated in a) initially - the addition of the field twists the molecules out of their initial alignment. The molecules in this case function with induced dipoles.

Figure 9 shows how multiplexing can be used to drive a liquid crystal display. One layer of electrode connections on the upper surface links rows in common and the lower layer is connected with columns in common. If a given segment is required to be switched, then a pulse is applied to the corresponding row and the corresponding column. The additive effects of the two voltages will cause the display to change. Individual voltages on other segments will not appreciably change their brightness level. Data is typically communicated to each row in sequence to create the display.

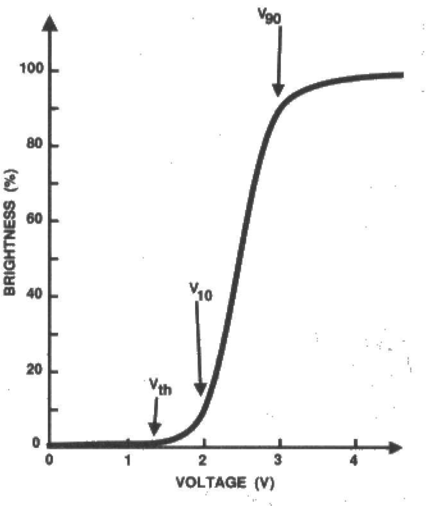


Fig.7 Details of the switching characteristics of a typical LCD display element. This curve determines the relative contrast of the display.

Where a large number of rows, N, are required to be switched, each row is only switched on for a fraction 1/N of the time. Where this results in an appreciable delay the display tends to flicker. It can help to use a liquid crystal which has a longer switching off time so that the details of the image are preserved as long as possible.

Display Technology

Early designs for liquid crystal displays tended to use the light scattering properties of liquid crystals for which voltages around 15V were required. It was the development of twisted nematic displays in the early 1970's which led to the rapid expansion in LCD technology and uptake.

Figure 10 shows the details of a twisted nematic display. Ambient light enters the display from above and passes

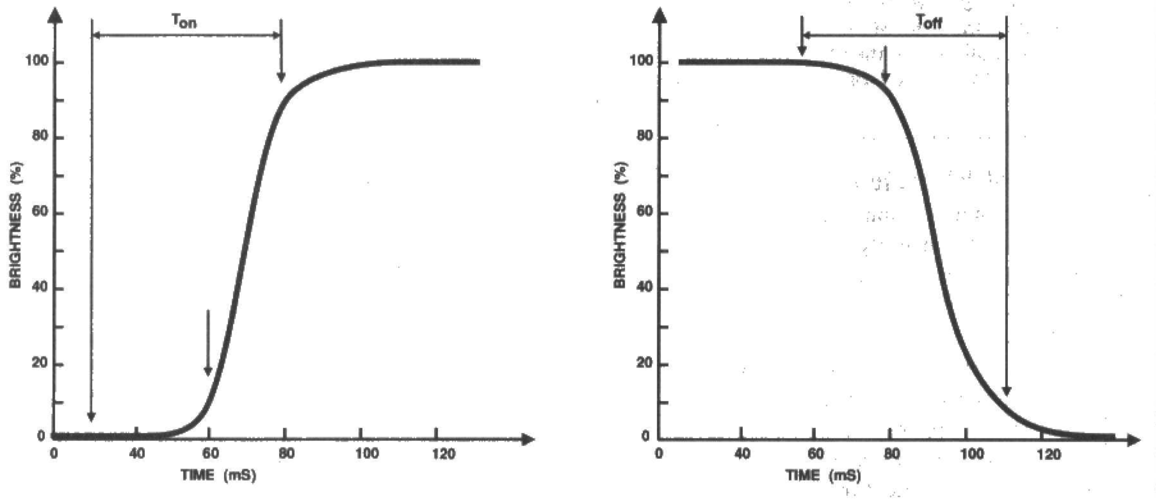


Fig.8 Typical turn on and turn off characteristics of a liquid crystal display element. There can be an advantage in having a longer ON-OFF time when a large number of elements are being multiplexed.

through the first polariser unit. The surfaces containing the liquid crystal are treated so that on the upper surface they lie parallel (flat on the paper) and twisted 90 degrees on the lower surface (in and out of the paper). This light then passes through the liquid crystal which due to its optical properties twists the direction of polarisation of the light through 90 degrees. The light can then pass through the lower polarising layer and is in turn reflected from the lower reflective layer. On passing through the liquid crystal on its 'return' journey, the direction of polarisation is again swung though 90 degrees so that the top polariser is in the correct orientation to let it through. Thus the light from such displays will be highly polarised.

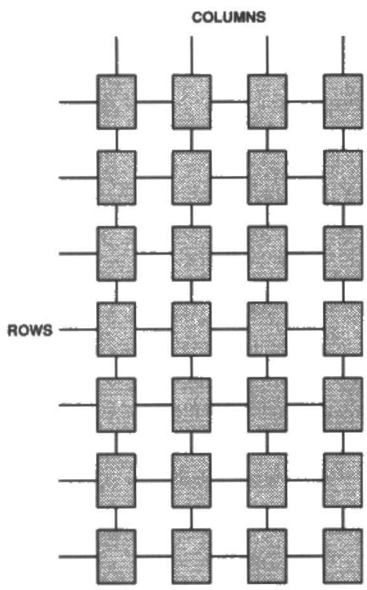


Fig.9 Connection details of multiplex lines to a 4x7 LCD array. Separate connections drive all elements in rows on the upper surface with separate connections driving columns on the lower surface. Only elements activated at the same time by an upper and lower drive signal will be active.

When a voltage is applied to the electrode surfaces on either side of the liquid crystal, the alignment of the liquid crystal is changed and only a small amount of light can pass across the crystal and out again. The display will then appear dark. If the voltage is removed the liquid crystal will adopt its previous 'twisted' orientation and the display will appear bright.

This 'twist' design can be adapted to suit a range of display requirements. The technology can be used in transmissive mode also such as is used in domestic sound systems and car radios. In this application the reflective layer is removed and replaced by a light source. Light passes through the first polariser and then is twisted 90 degrees to pass through the second polariser. When the polarising voltage is applied, the liquid crystal cannot rotate the polarisation direction of the light and the display appears dark.

This technique of crossed polarises suffers from several disadvantages. One is the fact that each polarisation interface reduces the transmitted fraction of light by at least half so the two passes reduce light by about a quarter. Such displays are best viewed 'straight on' and there is a significant reduction in contrast when the viewing angle is increased. The switching times of such displays are in the region of 0.02 sec to 0.05 sec and this has limited the range of applications for which they can be used.

The super twisted nematic (STN) display was introduced in 1985. This rotated the direction of polarisation through 270 degrees instead of 90 degrees. This arrangement of the liquid crystal provides for a sharper characteristic response with voltage and better clarity with viewing angle. A recent development has been the double super twist device where two liquid crystal cells which lie on top of each other can be independently switched. The twist of each cell is in opposite directions and helps compensates for wavelength response - providing a sharper contrast.

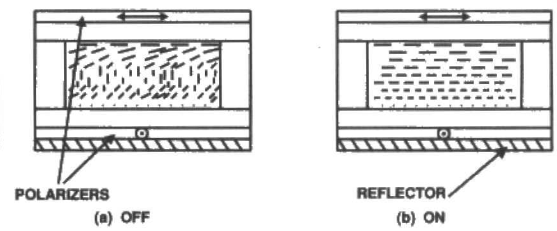


Fig.10 Diagram of widely used twisted nematic liquid crystal display. The unit shown operates with ambient light. The uper polariser polarises light in the horizontal direction 'in the paper'. This passes through the liquid crystal which rotates the direction of polarisation 90 degrees so that it can be passed by the lower polariser and reflected back through the liquid. In this process the direction of polarisation is rotated back through 90 degrees so that it can be passed by the top polariser. When the field is applied, the liquid crystal is prevented from 'twisting' the light and no light is passed by the lower polariser.

Implementing Colour

While liquid crystals themselves do not readily exhibit useful colour effects, use can be made of the so called 'guest-host interaction' where dichotic dyes are mixed with liquid crystals. Such dichotic dyes absorb certain wavelengths of light of polarised light in preferential directions relative to one axis of such molecules. The dye molecules align themselves with the liquid crystal molecules and as the liquid crystal molecules twist or rotate so do the dye molecules.

Figure 11 shows a unit where there is a top polariser and a liquid crystal whose molecules are aligned in the off state parallel to the direction of polarisation. The dye molecules are aligned with the liquid crystal molecules and absorb most strongly a specific set of wavelengths in this orientation. The light is reflected back as being brightly coloured. When a voltage is applied across the liquid crystal, the dye molecules

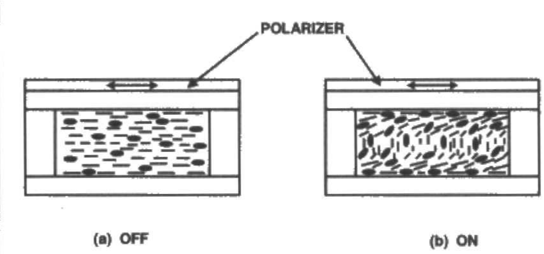


Fig.11 Utilisation of the 'guest-host' liquid crystal which includes a dichrotic dye which lines up with the liquid crystal molecules. The dye molecules are strongly absorbing of specific wavelengths of light when in a) the OFF state and the display appears brightly coloured. When the electric field is applied this property is lost as the molecules tend to align parallel to the electric field direction and the bright colour is lost.

are moved out of their direction of preferential absorption and the colour effect is lost. This type of display only requires a single polariser and reduces the amount of light lost in the display.

Enter Polymer Dispersed LCD

A recent development in liquid crystal display technology is in polymer dispersed displays. This technology has been particularly developed for applications requiring LCD areas as large as a square metre. This technique uses polymer to

'contain' the liquid crystal which is in fact embedded within the polymer in micro spheres as shown in figure 12. Within each micro droplet the liquid crystal tends to align its molecules in two phases - one with the director pointing towards the centre of each microsphere and one where the director aligned parallel to the surfaces of the sphere. With no electric field applied these micro spheres are aligned at random within the polymer. The refractive index of the

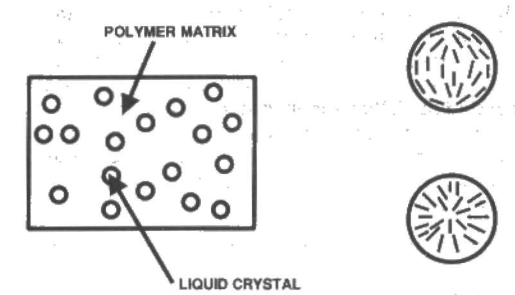


Fig.12 Details of polymer dispersed liquid crystal structures. The liquid crsytal is contained in spheres contained with a layer of polymer material. The director of the liquid crystal molecules (line up direction of molecules) can occupy two states as shown in b) - parallel to spherical surfaces or at right angles to spherical surfaces. When the director of the liquid crystal lines up with an applied field, the light which falls directly interacts primarily with these liquid crystals.

polymer and the two directions of propagation of light relative to the director within the crystal will be different because of this random orientation and this causes the light to be reflected strongly from the liquid crystal micro spheres.

Where an electric field is applied so that the microspheres align with the director facing perpendicular to the electric vector of the incident light, there is a dominant refractive index associated with this propogation direction. If the refractive index of the polymer is made equal to that of the propogation of light in the perpendicular direction, then greatly reduced reflection results across the liquid crystal micro spheres - the display will be clear.

Fabrication of LCD Devices

As with all highly developed technologies, there are very definate guidelines to follow to produce reliable products. Up until recently, glass has been the dominant material with which to fabricate LCDs. It has been shown that high levels of Sodium or Potassium ions in the glass can cause problems by their migration into the liquid crystal. This problem has been overcome either by using glass which is low in their ions or by coating the surface of the glass with silicon dioxide, but now, plastic is becoming increasingly popular as a replacement for glass.

Indium tin oxide is deposited in a thin layer on the inside of the 'sandwich' in order to apply the electric field across selected areas of the display. Such layers are typically around 25 nm thick and transmit up to 80% of the light incident on them. The 'mask' of connections is so configured that connections are only allowed to overlap on the two surfaces where a display is required.

It is important for correct function of a typical LCD device that the liquid crystal molecules are made to orientate correctly with respect to the containing surfaces. Most displays establish the liquid crystal molecules parallel to the glass surfaces - in the homogeneous texture. This configuration is typically achieved by stroking the glass surface with a long chain polymer such as polyvinyl alcohol.

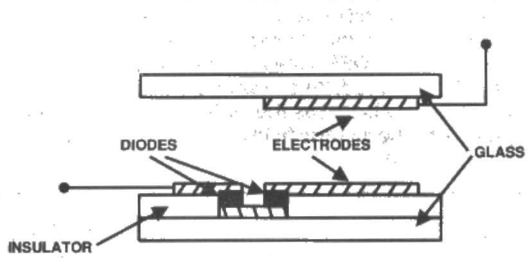


Fig.13 In the active matrix display, the drive signal is modified by a back to bck diode. This sharpens the response of the LCD element and allows increases the degree of multiplexing possible. Such technology has been used for pocket colour televisions.

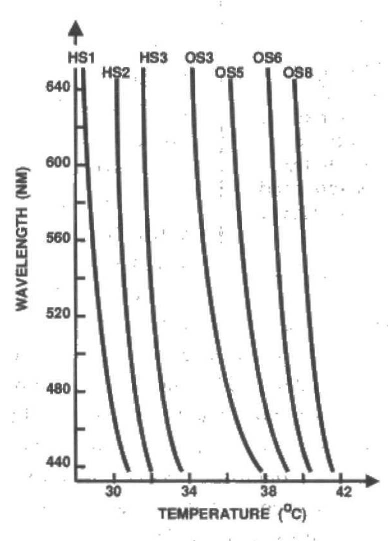


Fig.14 Set of wavelength response curves for a series of chiral nematic liquid crystal mixtures. Each set is designed to respond within a range of 2 degrees C.

When the LCD unit is fabricated, the distance between the plates is of critical importance. This determines, for example, the value of electric field within the liquid crystal when the device is activated by a set switching voltage. The separation of surfaces on a LCD unit is typically between 5 and 25 microns. Sometimes transparent spacers are used to hold the devices apart by the correct amount as such devices are fabricated and sealed.

Active Matrix Displays

Rather than have the LCD unit as the device which is sent drive signals deleloped by electronic circuits elsewhere in a system, the technique of active matrix displays employs in situ-semiconductor devices to control individual pixel ele-

ments. Figure 13 shows how the drive signal for a pixel is connected across a back to back diode and the liquid crystal cell. This sharpens the individual cell characteristic and allows a higher degree of multiplexing for large area displays. Such technology is being used, for example for pocket colour televisions. LCD television screens can be obtained in six inch screen sizes and it is predicted that a twenty inch flat panel screen will be developed by around 1995.

Liquid Crystal Temperature Sensors

When white light strikes a chiral nematic liquid and travels along its twist axis, then only light of wavelength similar to the pitch of the liquid crystal is reflected back. This wavelength is highly temperature dependent and so the colour reflected can be used as an estimate of temperature (Figure 14). By choosing suitable sets of compounds, such temperature sensors can be made to change from blue to red over as small a temperature range as 1 degree centigrade.

Summary

The market for such LCD devices is indeed set to grow dramatically as all manner of devices become practicable due to the availability of compact flat screens. While cathode ray displays may have been big and bulky, they certainly have been reliable and the hope is that LCD screens will have the same reputation for lasting a lifetime.

The Spoiler

by Anal Bardfrod

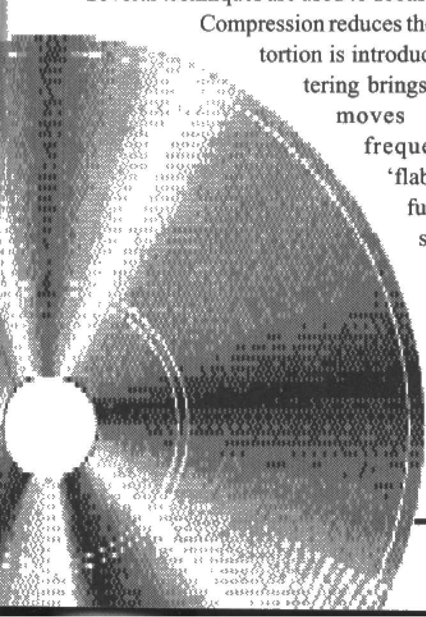
As the second millenium approaches and we are at last grasping pefect fidelity of audio reproduction, as the 32 bit, 180 times oversampling DACs are bolted onto each channel, as the palladium free copper cables are placed parallel to the ley lines, as the resonance-free cellulite foam platens support the three irregularly placed pyramidal legs of the CD player, is there not among all the mumbo-jumbo at least a suspicion of betrayal?.

Why is it that the record that sounded great on the AM tranny is so thin and unspirited now its in the hi-fi? How come the perfect audio device emasculates half the material it's given? Why is hours of listening to CDs enough to induce fatigue?

What is wrong?. What has happened to the dream? Have we in our headlong drive toward abstract perfection, lost our way? Have we instead achieved a distillation devoid of all flavour? Is this perfection really a siren, leading us ever onward to eventual bankruptcy? Is there any going back?

Do not despair: we present the solution. This design can make even the most tiresome CD system sound like a Dansette. This is the one for all those saddled with state of the art systems and yearning for what they have lost.

Several techniques are used to debase the sound 'quality'. Compression reduces the dynamic range, distortion is introduced and bandpass filtering brings out warmth and removes annoying high frequencies. A unique 'flabby earthing' method further muddies up the sound image, some noise is added and an optional 50/100Hz oscillator may be used to inject hum if desired. The circuit is designed to be inserted between the CD player and the amplifier.



HOW IT WORKS

The input signal is mis-matched and attenuated 100 times by R1 and R2 prior to being amplified by Q1, a single stage amplifier with a gain of 100. From here it passes to the compressor built around 161. This is a CA3080 operational transconductance amplifier chosen for its poor noise performance and restricted input voltage swing. The output of IC2b is rectified and smoothed by D2, R13 and C5 and fed to Q2 which sources the control current for IC1, C4, R10 and R11 tailor the frequency response of the side chain such that the mid range is compressed least, while the time constant of C5 and R13 is chosen to introduce 2% of modulation distortion (the least audible amount), particularly at lower frequencies.

After compression the signal passes on to 164 where network C5, R15 and R16, together with R17 and C7, tailor the overall frequency response to bring out the 'warmth' in the music. The important thing to note here is that the biasing resistors R18 and R19 are not decoupled, severely impairing the stiffness of the 'ground' connection.

IC5a and IC5b form a crude astable oscillator running at 50Hz, with a strong 100Hz harmonic; it is not necessary actually to connect this oscillator into the audio path - sufficient hum is induced by proximity and by running the oscillator from the same power supply (which should not be regulated) as the audio circuitry.

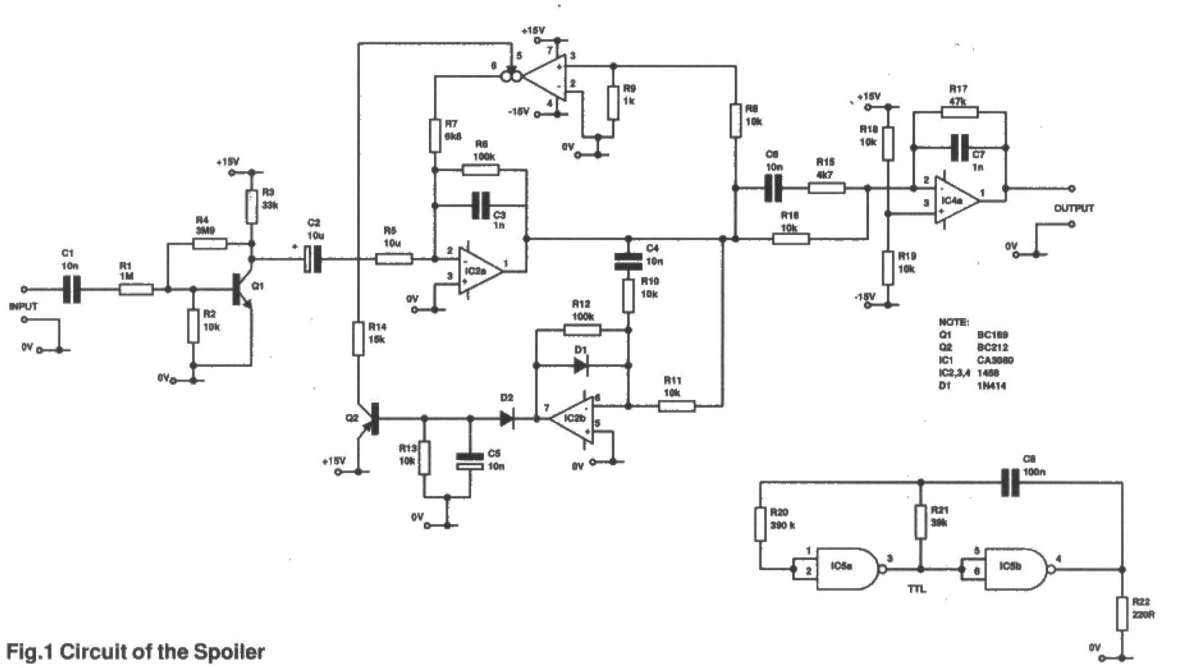


Fig.1 Circuit of the Spoiler

In Use

The spoiler is effective on a wide range of digital recordings and does much to set listening back 30 years. If it is wished to build a stereo version the above circuitry should be duplicated and located inside the electric toaster.

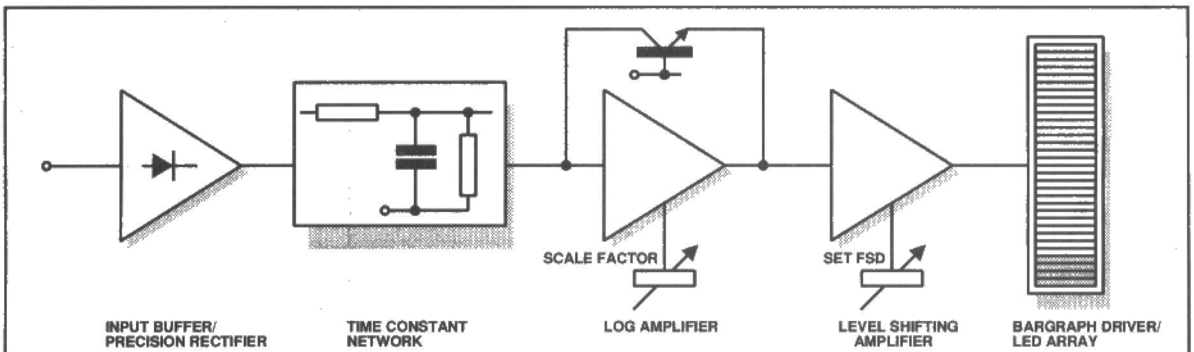
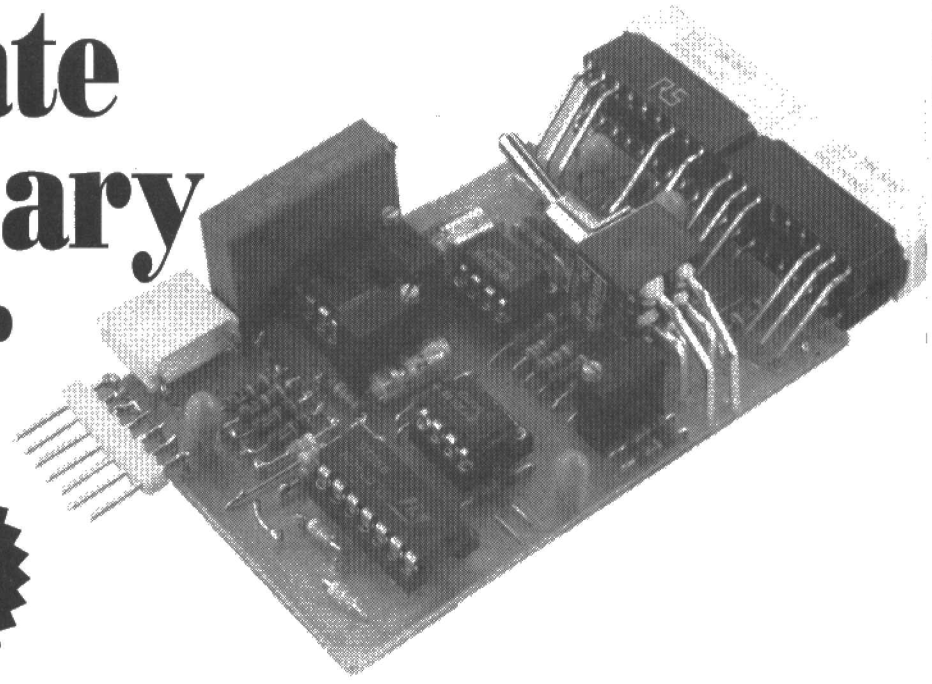


Fig.1 Block diagram of Automate LED Peak programme meter

AutoMate Anniversary Mixer



ETI Cover PCB Project

Peak Programme Meter

This project covers just about all eventualities. Mike Meechan explains.

As the AutoMate project today is now a toddling one year old, (but still teething), we take a brief respite from things purely theoretical and present a front cover PCB project which is, incorporated into, and used with, the AutoMate mixing desk (Group/Monitor section). The board, however, is not intended solely for use with this project and could be fitted to a great variety of audio-related projects, where an accurate visual means of determining audio levels at a particular point in the signal pathway is required.

It could be fitted to just about any type of pre-amplifier, mixer or amplifier. Some of the more specialised theory and background information about metering in general, and PPM's specifically, was explained in last month's issue. I hope that this hasn't been to the detriment of this month's instalment. Those interested but not following this series may like to refer to the March issue.

Last month, we looked at the various types of meter which abound in an audio environment, and then explained what it was about the PPM which made it so special.

Being LED Astray

We mentioned that there were two types of meter in common usage. If the VU type is the first, and the PPM type is the second, the third, slightly hybrid option for metering is the LED type. It is upon this type that we'll develop the AutoMate design. By using the appropriate electronics, any ballistic response, from VU to PPM to a combination of the two can be recreated. Unfortunately, the ICs available for the driving of bargraph displays such as these have threshold points not ideally suited to our purpose. As an example, the LM 3914 has a linear response, the LM 3915 a 3dB log response and the LM 3916 a semi-log (VU) response. Also, for good resolution, at least two and preferably three of the devices need to be cascaded. This approach starts to become a prohibitively expensive way of obtaining our metering circuitry.

However, proper moving-coil PPM's *are* expensive and can't really be justified for most of the simpler and less demanding domestic or semi-professional applications. I

PROJECT

NOTE:

IC801	TL074 (IC801a NOT USED)	D801 - D804	1N4148
IC 802	TL071	ZD801,2	8V2 ZENERS
IC803	TL072	IC806 (IF FITTED)	SSM2210
IC804,5	TSM39342 (OR 39341 IF RED DSPLAY REQUIRED)	Q801,2 (IF FITTED)	ZTX108C

V_A = AUDIO SUPPLY V_S = SWITCH SUPPLY

COMPONENTS MARKED WITH AN ASTERISK (*R801) ARE LIABLE TO OMISSION OR CHANGE IN VALUE IN THE VU VERSION. C805 NOT FITTED TO PEAK VERSION. LINK 11 IS SHOWN FITTED. THIS IS THE BOTTOM MOST CIRCUIT (IN A CASCADED ARRANGEMENT)

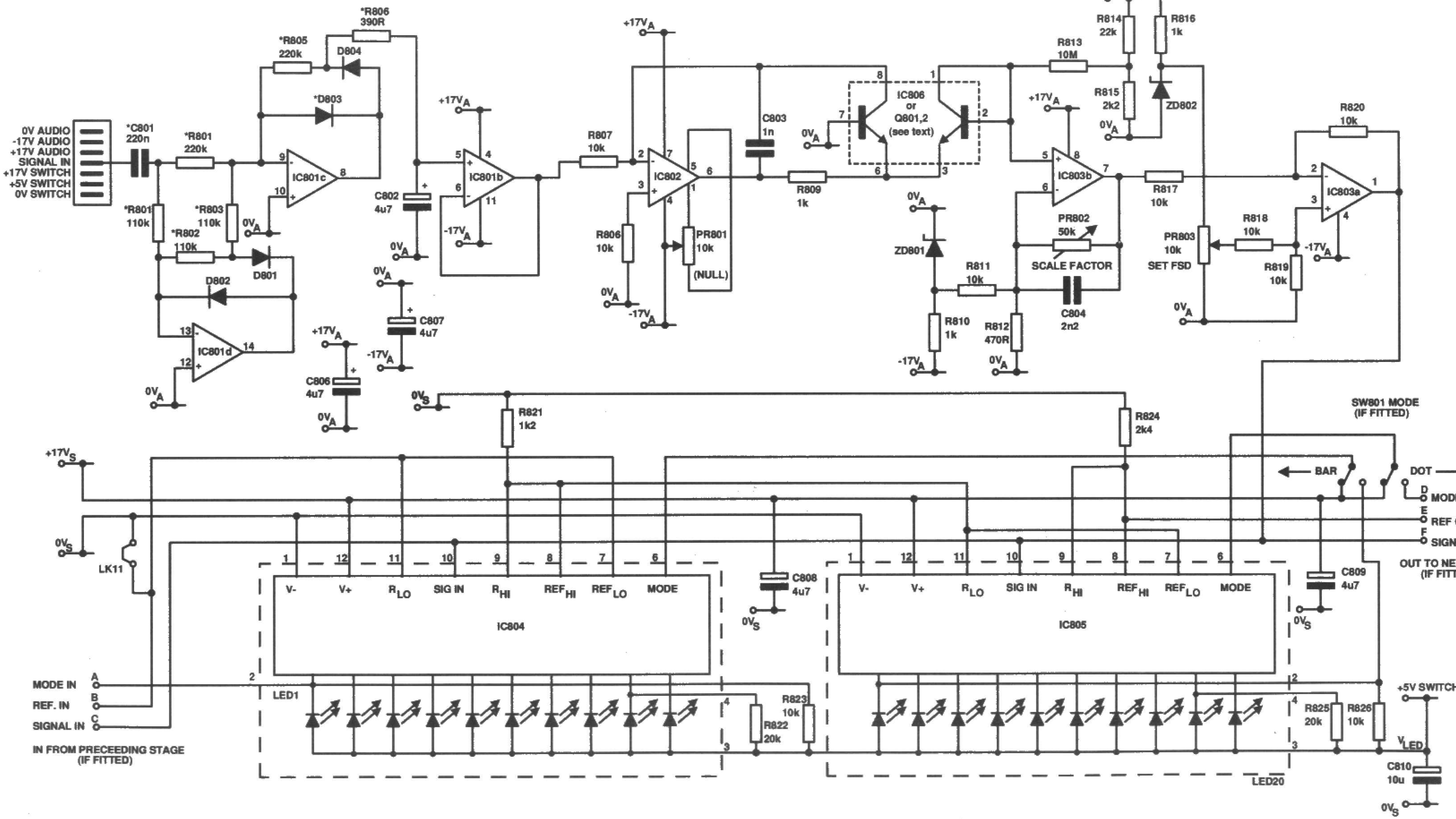
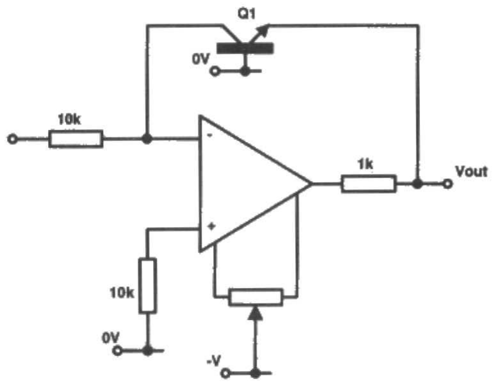


Fig.2 Circuit diagram of PPM



$$I_E = I_o' \exp\left[\frac{eV_{BE}}{KT}\right]$$

$$\text{for } h_{FE} > 1,\ I_C \approx I_E$$

$$\therefore I_E = I_o' \exp\left[\frac{eV_{BE}}{KT}\right]$$

$$\ln I_C = \ln I_o' + \frac{eV_{BE}}{KT}$$

$$V_{BE} = \frac{KT}{e} \ln \frac{I_C}{I_o'}$$

$$I_F = I_1 = \frac{V_1}{R_1}$$

$$V_O = V_{BE}$$

$$= \frac{KT}{e} \ln \frac{I_C}{I_o'}$$

$$= \frac{KT}{e} \ln \frac{V_1}{R_1 I_o'}$$

Fig. 3 Basic log amplifier

have therefore designed an LED peak programme meter which has many of the benefits (and the accuracy) of the true moving coil PPM but costs considerably less than its more illustrious, full-pedigree relation. Once fitted with the full complement of 20 LED's, measurement accuracy is to within 2dB in the standard set-up, although scale resolution can be made more or less depending upon the application.

I have used a log amplifier to create a linear input voltage for two cascaded LM 3914 linear bargraph driver/display IC's, each LED of the bargraph nominally representing a 2dB change in level. The input to the log amplifier comes from a precision rectifier/time-constant circuit. The rectifier allows the meter to accurately follow the peaks in the program while the time constant network is used to synthesise the correct rise and decay time for the PPM ballistics. For those constructors wishing to experiment and who wish greater or less meter resolution, or a different full scale deflection level, provision has been made on the board for adjustment of both of these parameters. In this way, the amplifier response can be tailored so that the same range can be represented on fewer (or greater) LED's. Figure 1 shows a block diagram of the system.

A recent innovation in the field of bargraph modules is in

HOW IT WORKS

Peak Programme Meter

The meter circuitry can be split into the five sections shown in the main text. We'll look at each in turn. Refer to the circuit diagram shown in Figure 2.

Precision Full-Wave Peak Detector/Time Constant Network IC801a and 801b form a conventional precision rectifier, the output of which feeds a large-value capacitor, C802.

Whereas DIN 45406 calls for a response of 1dB down from a steady-state for a 10ms tone burst and 4dB down for a 3ms tone burst, BS 4297 requires an integration time of 12ms and a decay time from 7 to 1 of 2.85.

R806/C802 form the necessary attack time constant of 1.8ms. Despite quoting 2.5ms last month, for an inertialess meter which provides no damping or filtering (as the moving-coil type does), 1.8ms calculates to be the correct time constant in this instance. As noted above, BS4297a specifies 2.85 for a decay from PPM 7 to PPM 1 (24dB). One time constant equates to a decay of 8.4dB and is met by a value just less than 15. The specified return time is met by R805, R806 and C802. Figure 12 gives the correct resistor values for each of the different types and available values of capacitor.

This circuit was intended originally to connect directly to the high impedance signal input of the LM3914/15/16 series of bargraph driver IC's. The log amplifier circuit is not of the correct impedance and loads the network 'appreciably, so a buffer, IC 801c, is interspersed between the time constant network and the log amplifier input terminal, IC802 pin 2.

Log Amplifier

A logarithmic amplifier gives an output of the form Vout = Alog k Vin where A and k are constants. Such amplifiers are used extensively for instrumentation purposes where they allow a wide range of different values to be represented on a single scale since each division can then represent one decade.

Since acoustical measurement work use the Bel and its smaller brother, the decibel, a logarithmic amplifier connected before the display driving circuitry can provide for readings to be made directly in decibels, thus allowing a wide dynamic range to be represented on a single, linearly-annotated scale marked directly in dB.The basic circuit of a logarithmic amplifier is shown in Figure 3. This uses a transistor in the feedback loop of a conventional virtual-earth inverting amplifier, with the output series resistor included as a protection device to limit the current which the transistor base-emitter junction can draw from the op-amp with high level input signals. The emitter current of a bipolar transistor is related to the base-emitter voltage voltage by a form of the pn junction equation

$$I_E = Io' \exp(eV_{be}/kT)$$

for h>>1

Therefore

$$Ic = Io' \exp(eV_{be}/kT)$$

where Io is the reverse leakage current, e is the charge on the electron, k is Boltzmann's constant, T is the absolute temperature. The natural logarithimic form is as follows:

$$\ln Ic = \ln Io' + eV_{be}/kT \text{ ie } V = (kT/e)\ln I_C/I_{B'}$$

where, as is usually assumed with the virtual earth at the op-amp inverting input,

$$I_F = I_I = V_I/R1$$

We should note that the feedback current I forms the collector current Ic of the transistor as shown in Figure 3. It follows, therefore, that:

$$Ic = I_F = V_I/R1$$

Since the emitter-base junction is connected directly between the output and earth, the output voltage

$$Vo = V_{BE}$$

$$= (kT/e)\ln(V_I/R1I'o)$$

Thus, we have an voltage at the op-amp output which is proportional to the natural logarithim of the input. This is readily expressed in the form of log x = ln x log e. The new, more common form simplifies to:

$$Vo = b \log V + c$$

where b and c are constants.

The input/output transfer characteristics for this simple log amplifier are shown in Figure 4. It is clear that the output voltage swing is small, changing by about only 0.3V over four decades of change at the input. For low magnitudes of input signal, offset voltages become critical and a fine-tuning offset null control is used to null the output under no-signal conditions. In this condition, the current in the feedback transistor is negligible and the op-amp is operating near its open-loop condition so adjustment is critical.

Another shortcoming associated with this simple log amplifier is that it is sensitive to changes in ambient temperature because of the

the introduction (by National Semiconductor) of hybrid packages which combine both the LED's and the bargraph driver electronics in a single IC. There are both vertical and horizontal types, with the horizontal one similar to the DIL LED bargraph packages which now prevail, but with fewer legs along the bottom edge. The horizontal type looked particularly attractive, not least because the overall cost of the LED/driver package was little more than that of ten discrete rectangular LED's. Unhappily, it proved difficult to mount at right-angles to the PCB surface without a special 18 pin right-angled DIL socket - not readily available -and the LED's came in only two colours (incorporated into the whole block) ie each package has ten LED's which are the same colour.

The expense problem of the discrete LED's and driver chip was the main one, and obviously, was directly proportional to the number of bargraph driver IC's employed. However, when the alternative cost and complexity of twenty or so discrete comparators, precision resistors and greatly complicated PCB is considered, I think the chosen option is infinitely preferable (and probably a good deal less expensive). Regrettably, it doesn't allow the staggering of LED colours and sizes but that's life....

Natural Evolution

At first, in the original prototype, I used the LM3914 bargraph drivers and discrete LED's. Two major difficulties became apparent. It proved impossible to mount the LED's at right angles to the PCB - their normal attitude - and still have them retain a uniform, flat, block-like appearance. Even minor differences in the leg bending point (probably in the order of fractions of a millimetre) manifested themselves as a distinct unevenness on the surface of the LED cluster and a corresponding loss of professional finish. I experimented with a variety of different methods - and used a lot of LED's

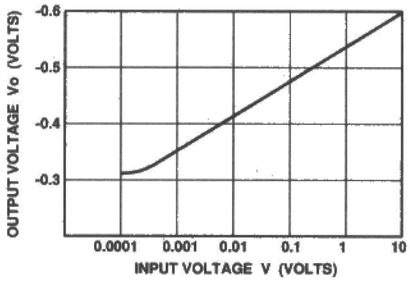


Fig.4 Transfer characteristics

kT/e factor in the equation.

Both of these problems inherent to the simple, single stage design, can be solved by adding a second stage, as in the featured design. This boosts gain and provides temperature compensation. The second base-emitter junction of Q802 or the second half of IC806 acts in opposition to the main logging transistor since it encounters identical changes in temperature, and so resultant changes in its base-emitter PD compensate for the variations in Q801. Despite this, it experiences only a negligible change in operating current over the full range of input signals and so does not tend to counteract the logging action of Q801.

For good temperature compensation, therefore, it is imperative that the two transistors are mounted as close as possible to one another and so encounter an identical thermal environment. The ideal is to use a supermatched pair where the two transistors are mounted in the same package and have identical electrical characteristics. For those wishing better accuracy and insensitivity to temperature, this is an option which has been included on the board, with the optional IC806 in the parts list being the supermatched pair, and Q801 and 2 the discrete transistors. Figure 5 shows a graph of Vout versus Vin for this compensated log amplifier.

C803 and C804 shunt both of the feedback loops and so maintain high frequency stability under all conditions. PR801 nulls the first input stage and is adjusted so that as the input tends to zero, so the output tends to zero. It is not, however, adjusted with zero input but with a very small magnitude signal voltage, since log 0 is equal to minus infinity and the amplifier output tends to behave very strangely indeed. PR802 adjusts the gain of the amplifier (scale factor) and is adjusted for around -1.2V per 20dB change in input (in a non-cascaded board). When cascading boards, it can be altered to give -1.2V per 10dB change in input level.

Level Shifting Amplifier

This is a differential amplifier created around IC803a. The signal to the non-inverting input comes from PR803, which is fed in turn from ZD801 reference voltage. This is used to set the pedestal voltage upon which the output sits and so adjusts full scale deflection. The inverting input is fed from the output of IC803b. The output from pin 1 is a positive-rising voltage in the nominal range 0 to 4.8V. This is fed to the signal input pins of both bargraph drivers.

Bargraph Driver/Array

This section uses the National Semiconductor LM3914 bargraph driver/LED array. This is a very versatile IC and incorporates both ten LED's and associated drivers in a single package. The IC is designed to drive the LED's in response to an analogue voltage input, with the chosen modules having a linear relationship between the input voltage and the number of LED's lit. Others in the series follow a logarithmic law - the LM 3915 - or VU (semi-logarithmic law) - the LM3916.

A number of notable features include:

Bar or dot display externally selectable Internal voltage reference LED drive current programmable from 2 to 30mA

Functional Description
Input Buffer and Comparators

The block diagram of Figure 6 shows the internal architecture of the IC. Signals are inputted to it via a high impedance buffer, with the output signal from this fed to a series of 10 comparators. Each of these is biased to a different threshold voltage level by the resistor string. The values of the resistors within this string, therefore, determines the characteristics of the display, with the linear scaling of the resistors within the LM3914 creating a linear scale. In the example shown (and indeed in the featured PPM circuit), the high end of R is connected to the internal 1.25V precision reference. For the LM3914, this means that there is 0.125V impressed across each resistor, so that for each 125mV increase in input signal level, another comparator will switch on. The R pins can, however, be connected between any two voltages, within the constraints of the IC maximum operating conditions.

Internal Voltage Reference

This reference may or may not be used to impress 1.25V across the resistor string. Both ends of the reference are available externally (REF OUT and REF ADJ). Further, this voltage is applied across a 'programme' resistor which, because the source PD is fixed, generates a constant current. This is used as an error term in a feedback loop and helps to minimise changes in this current with changing V+ and load currents. Connected with this reference - no pun intended - is the ability to programme LED on currents (a display brightness control). LED drive source current is equal to ten times that drawn from the REF OUT pin. R and R programme the PPM LED drive currents in our example.

- but was unable to improve matters to any noticeable extent. I returned therefore to the original idea of the combined display/driver IC. This solved the second problem which was in the difficulty of physically fitting all of the components into the available PCB area. The area occupied by the LED and bargraphs was reduced by about 50% when both were combined. The problem of the right-angled DIL sockets remained but I devised a scheme to fabricate these from a

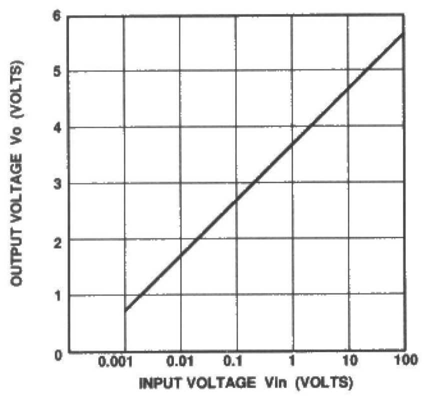


Fig.5 Transfer characteristics of Automate temperature-compensateed log-amp

wirewrap type. The colour problem was also tackled. More details in the Construction section. This LED type however, is not without its drawbacks. The displays need power supply rails not associated with the moving coil type, with a current sourcing capability directly dependent upon the number of LED's in the display.

Research has also shown that many operators find prolonged use of the LED meter to be irritating and wearing on the eye, far more so than with the moving coil type. A further failing of the PPM generally, not LED ones specifically, is in the way that it gives no indication of the subjective loudness of the material and so speech, say, must be allowed to peak to PPM 5.5 whilst heavily compressed pop might only be allowed to peak to PPM 4. We mentioned this briefly when we discussed the choice of PPM time constant. It is also one of the reasons why I said that in last month's issue the VU meter fitted with a peak LED is an ideal combination - some indication of subjective loudness is given *and* we can be alerted to any potentially damaging peaks, all in the same instrument package.

Anyway, enough of the negative aspects. The featured design can be tailored to the individual's needs in a variety of ways. Both full scale deflection and scale factor are readily adjustable to suit personal preferences. Buffering of the input circuitry means that there are no loading effects and the input gain (or loss as the case may be) can be adjusted ie variable sensitivity. The PPM, therefore, can be interfaced with just about any type of audio equipment. If desired, either for greater accuracy within the original range, or to maintain similar accuracy across a wider dynamic range, identical modules can easily be cascaded to produce larger displays. The units depicted on the front cover are in fact the original prototypes. These can be switch-selected for bargraph or dot mode. Finally, for those stalwarts who prefer the ballistic response of the more traditional VU, I have included on board provision to recreate this type of response. It is a simple matter to alter a few component values and to swap some capacitors and diodes. As an aside, it is sometimes useful to be able to switch between VU and PPM type characteristics. Many mixers provide this facility, but the

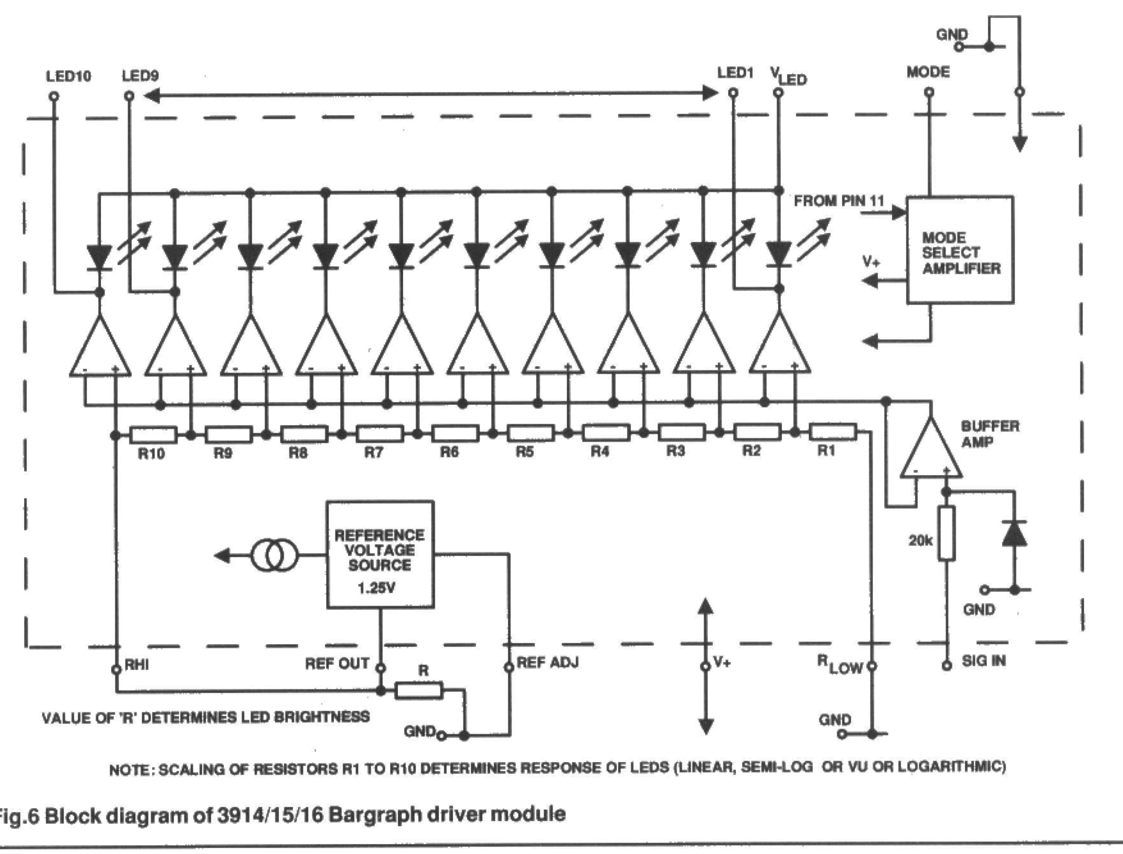


Fig.6 Block diagram of 3914/15/16 Bargraph driver module

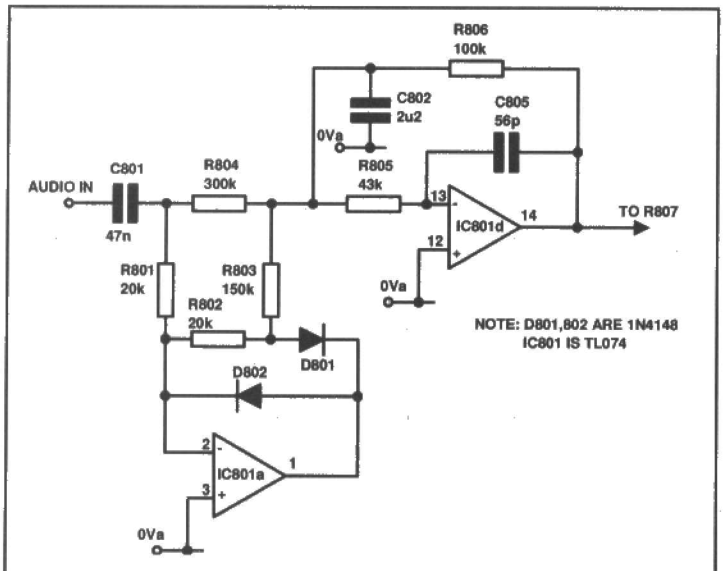


Fig.7 Modifications to input circuit to create VU meter response (to ANSI specification C165)

any case, on a board intended for use solely by itself. Figure 8 shows the bottom-most board of a cascaded display (or a board for use by itself) while Figure 9 shows the way boards are cascaded.

Links are followed by Veropins, and the horizontally-mounted IC sockets. At this point, decide whether or not it is the discrete transistor or super-matched pair version which you are building. The discrete transistor type behaves reasonably and will suffice in most applications, but is prone to small errors should ambient temperature change by anything less than a small degree (no pun intended). The super-matched version, while being more expensive, doesn't suffer in this way because the transistors are perfectly matched and track each other accordingly. Don't be tempted to skimp on the Veropins since they are much less expensive than a new PCB. More about the reasoning behind this coming soon...

serious restrictions caused by the small physical size of the PCB meant that I couldn't include this as a viable option on a board this size. The main console monitoring, does, however, include this facility.

Continued Next Month

Construction

Construction is reasonably straightforvard, if a little time-consuming. As a consequence of the size and density of the PCB, many of the tracks are fine in width, with some passing between adjacent pads on a DIL section. I strive whenever possible NOT to do this with my board layouts, but in this instance, there was no choice. What this means to you as a constuctor is that great care, a lot of patience and most importantly, a fine-tipped soldering must be employed during construction of the board. All wire links should be inserted and soldered first, with special care taken that the link - LK 6 -which resides underneath IC 806 (if this is fitted) is not forgotten. There is a similar such link - LK8 - situated partially underneath C802, the main time-constant determining capacitor. (This statement holds true only if the time constant capacitor is a polyester or polyester-layer type).

At this point, the constructor must decide whether or not boards are to be cascaded, and if this is the case, whether the board currently being worked upon is going to indicate the smallest signal levels. Should this be the case, Link 11 must be inserted since this grounds the bottom of the reference/resistor chain. Otherwise, pin A should be soldered in its place and this is connected to pin F on the previous board (Ref Out on the preceeding stage). Link 11 is made, in

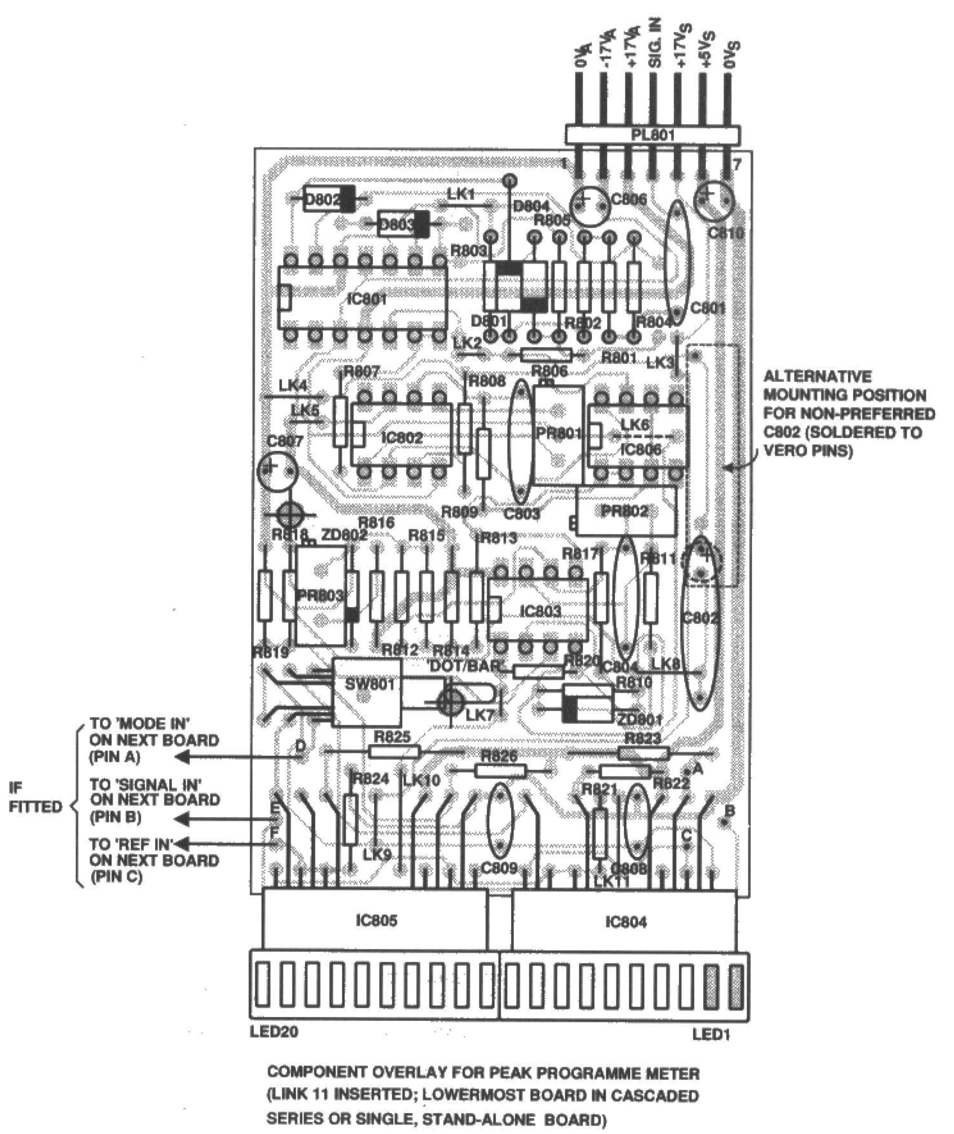
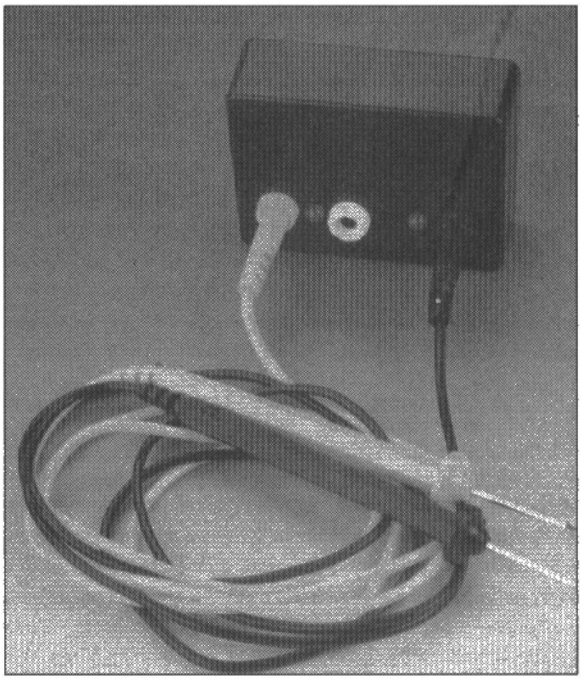


Fig.8 PPM component overlay (No. 1)

The Multimate Tester

Check polarity, continuity and AC or DC with this simple indicator. Construction by Keith Garwell.



Mais oui (but yes, literally), however it does have a number of useful features. The circuit is curious and makes use of certain properties of semiconductors which are sometimes overlooked and are worth discussion. Above all it's cheap, there is no range switching, it accepts up to 240V AC or DC and includes a check for continuity. It is not polarity conscious but it does indicate polarity. It is ideal for monitoring computer data lines, for example RS232, and can be left permanently connected if desired. The given circuit will handle up to 100kHz with the transistors specified. No doubt it would go higher than this with a bit of experimentation and a change of transistors.

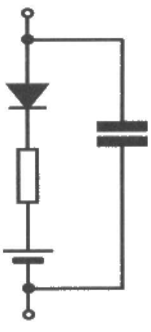


Fig.1 'Real' diode schematic

The circuit relies on the features of a semiconductor junction which we perhaps don't stop to think about very often. It's easy to get into the habit of thinking about diodes as perfect switches, on in one direction and off in the other. In practice it's not quite like that.

Figure 1 shows a 'real' diode which consists of a perfect switch (still indicated by the diode symbol) in series with a DC voltage source (indicated by the symbol for a cell) and a resistor. In parallel with this is a capacitor. Even so Figure 1 is not a perfect representation but it's sufficient for our purpose and indeed it's sufficient for many purposes.

The most important factor in what follows is the cell which represents a reverse voltage ie. it opposes the normal flow of current in the diode in the on direction. For silicon junctions the cell voltage is around 600mV at 20 °C and varies very nearly by 2mV/°C (they make good thermom-

HOW IT WORKS

At first sight the two LEDs look as though they will be permanently alight and indeed this would be the case were it not for the reverse voltage across them. Referring back to Figure 1 for a moment the cell voltage in these diodes is about 1.7 volts. In other words for the diodes to conduct more than 1.7 volts are required across each and in this case the two cell battery is not sufficient. A standard Leclanché type cell only gives 1.5 volts when new, consequently the two cell battery only gives 3V whilst the two LEDs would require 3.4V to light them in series.

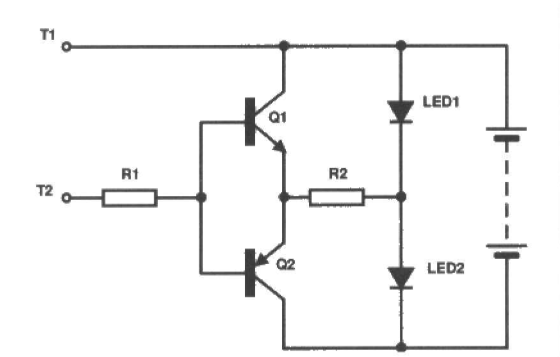


Fig.2 Basic Circuit tester

However, if one of the transistors is turned on its emitter-collector voltage is only about 0.1 volt. This would reduce the voltage across the LED with which it is in parallel to 0.1 also. As an example suppose Q1 is turned on then we have a circuit from the positive terminal of the battery, through Q1, R2 and LED2 to the negative terminal of the battery.

The voltage drops in the circuit are 0.1 at Q1 plus 1.7 at LED2 ie. 1.8 volts altogether. The battery however develops (if the batteries are fresh) 3.0 volts leaving a difference of 1.2 volts to drive current round the circuit. If R2 is 100R then the current is limited to 1.2/100 amps ie. 12 milliamps.

It is not necessary to use Leclanché cells, recharchargeables may be used instead. This gives a battery terminal voltage of 2.5 volts leaving 0.7 to generate current. This gives 7 milliamps which gives quite a bright light using high sensitivity LEDs.

Back with Figure 2, Q1 turned on causes LED2 to light and conversely Q2 on lights LED1. Now how are Q1 or Q2 turned on? A rhetorical question perhaps, but there are at least three answers.

Suppose T1 and T2 are connected to test leads. If the device is being used for continuity testing effective connection between T1 and T2 allows current to flow from the positive pole of the battery via T1, T2 and R1 to the base of Q1. Then via Q1 emitter through R2 and via LED2 to the negative terminal of the battery. Establishing base current in Q1 turns on the collector current and LED2 lights.

Suppose the test leads are applied such that T2 is positive with respect to T1. This generates the same condition as above ie. Q1 is turned on lighting LED2. The external potential reinforces the emitter current in Q1.

Now take the case where the test leads are applied such that T2 is negative with respect to T1. If we stick to conventional current flow then the positive input at T1 causes current to flow via LED1, R2, emitter-base junction of Q2 and via R1 and T2 to the negative side of the external circuit. With base current flowing in Q2 collector current flows also. Thus LED1 is illuminated by current from the battery via LED1, R2, Q2 emitter-collector and so to the negative side of the battery.

Well thats three cases, what happens if T1 and T2 are applied to an alternating potential? Answer - both LEDs light. At least that is how it appears. In fact the LEDs light alternately - one for each half cycle.

eters). For the junctions of LEDs the reverse voltage is usualy between about 1.5 and 1.8 volts.

The series resistor is around 100 to 200R for small junctions and becomes progressively smaller in value the more beafy the junctions become.

The parallel capacitance affects the frequency response of the junction but is only significant in our circuit above about 100kHz.

Figure 2 shows the basic circuit of the tester which at first glance looks like a bridge, but beware, it isn't.

In Practice

If the practical physical layout is such that LED1 is positioned adjacent to T1 and LED2 adjacent to T2 then whenever the test leads are applied to a circuit whichever LED lights indicates the positive terminal. Summarising the action in a table we have:

If T2 is positive with respect to T1	LED2 lights
If T1 is positive with respect to T2	LED1 lights
If T1 and T2 are connected together	LED2 lights

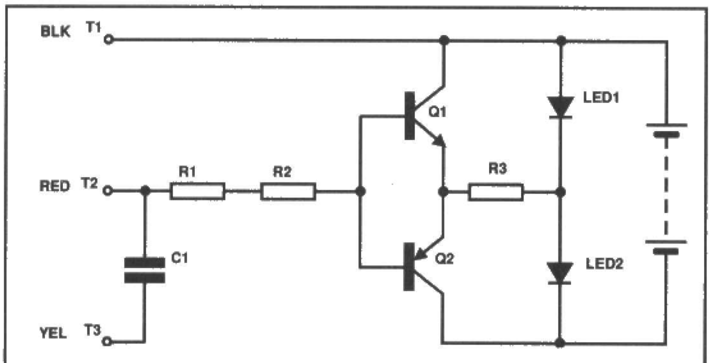


Fig.3 Final design of tester

This is completely unambiguous until the device meets a potential which is varying between zero and some other DC potential at more than about 10Hz such as would be the case with a computer signal eg. varying between 0V and +5V. The LEDs will merely indicate the positive terminal the LED turning on and off too quickly to be seen by the eye. This ambiguity can be resolved by providing a capacitor in series with the input and bringing it out to another terminal T3. Using this terminal and T1 in such a case will convert the pulsing DC to an alternating potential and both LEDs will light.

Finally to be practical we must decide on the maximum input voltage allowed. The mains is usualy the highest voltage we come across in these days of solid state electronics so this is what we will allow for in the design. This will determine both the ohmic value and wattage of the input resistor in Figure 2.

Half watt resitors are readily available and the new metal oxide resitors are good for about 0.6 watt. Using two 47k resistors in series each dissipating half a watt gives a total of 306 volts RMS, a nice safety margin above the 240V mains. 240 volt RMS gives a peak voltage of 340 and hence a peak base current of only 2.6mA in the two transistors which is quite acceptable. Using these figures the final design is shown in Figure 3.

Finally to recap we can draw up a useful table which will tell us what is happening in the external circuit depending on what the two LEDs are doing.

Alight	External
LED1	T1 is positive
LED2 dim	T1 and T2 linked
LED2 bright	T2 is positive
LED1 & LED2	AC voltage across T1 & T2

If in doubt about LED2 being dim or bright reverse the connections T1 and T2 if there is no change in the illumination of LED2 then no potential is present.

Construction

When finished the PCB is supported on the terminal sockets for the test leads see Figure 4. It is important therefore to ensure the holes for the terminals are in the correct position in the case.

The first thing is to position the board in the case and mark the holes for the terminals. To do this lay the board in the case copper side facing you and with the side remote from the holes marked T1, T2 and T3 in Figure 5 nearest the side of the case. ie. with the side of the PCB held up against the inside of the case the three holes for T1, T2 and T3 should be towards the centre. With the board held in this position drill through the holes T1, T2 and T3 and through the case itself. There is no need to use a drill the same size as the holes anything from 1/8 inch, 3mm downwards will do, the holes will be made larger later.

Next drill through the holes in the case with a drill to give clearance to the threaded part of the terminals (usualy 5/16 inch, 8mm). Then mark out and drill the holes for the LEDs. One is exactly half way between the centres for T2 and T3 ie. 0.4 inch from either and on the same line, the second is 0.4 inch inside the centre of T1. The hole size is 3/16 inch, (5mm). That completes the drilling in the case.

Now some drilling on the PCB. The terminal sockets will have a reduction at the start of the thread and it is on this reduction that the PCB will sit when finished, so enlarge the three holes in the PCB so that it will just fit over the ends of the sockets, see Figure 4 again for the arrangment. This hole is usually around 1/4 inch or 6mm but check with the sockets.

That is all the machining done, now to start assembly. First fit the terminal sockets into the case. If little keys are molded into the neck of the sockets file a small notch in the holes in the case to match before fitting. Then tighten the retaining nuts.

Now for the PCB. The first job is to set the height of the two LEDs above the PCB correctly. To do this insert but do not solder the two LEDs checking the correct orientation from Figure 5. Place the PCB in position in the case over the ends of the terminal sockets and adjust the two LEDs so that the ends just nicely come through the holes in the case. Solder the LED leads to the PCB and then remove the PCB and fit the rest of the components according to Figure 5. Trim all wire ends as appropriate.

Replace the PCB in position in the case (components downwards) over the ends of the terminal sockets and with the battery connection wires brought under it to the empty space in the case. Many of the small battery boxes for a pair

of AA cells such as used here have a PP3 type connector, so the battery wires need the corresponding plug. By means of some bare copper wire link the solder tags of the terminals to the appropriate adjacent rectangular pad on the PCB.

Fit two AA cells into the battery holder and check that neither LED is alight. Fit the test leads to sockets T1 and T2 and touch the probes together. The LED adjacent to T2 should light. If all is OK fit the lid to the case (which is in fact the bottom) and its ready for use.

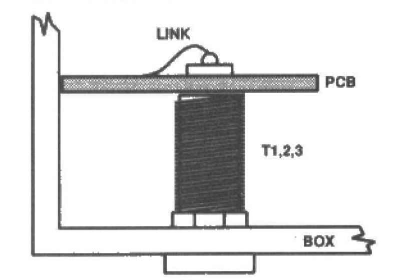


Fig.4 Socket arrangement

In Use

The usual connection is black test lead to black socket and red test lead to red socket. Connect the black lead to the reference point (earth or 0V) and use the red lead as the probe lead. Used in this way it exhibits the highest impedance to the circuit under test. Input capacity is low being only the test lead itself.

Notice that when the test leads are touched together the LED is not as bright as when the red lead is connected to a positive point. This enables the distinction to be made between continuity or two similar potentials and a potential difference being present. If reversing the leads makes no difference to the brightness of the LED then no potential is present.

To investigate pulsed DC signals use the connections black to black and red lead to yellow socket. The input impedance is the same as before and this arrangement has the advantage that the batteries are not used when no signal is present. It is convenient for example to leave the device connected to communications lines when the LEDs will light only when line activity is present

PARTS LIST

RESISTORS

R1,2	47k metal film
R3	100R metal film

CAPACITORS

C1	100n polyester

SEMICONDUCTORS

Q1	BC171
Q2	BC557
LED1,2	low current red 5mm LED

MISCELLANEOUS

T1,2,3 4mm black,red, yellow sockets respectively
Case,battery box 2xAA type, battery connector, probes

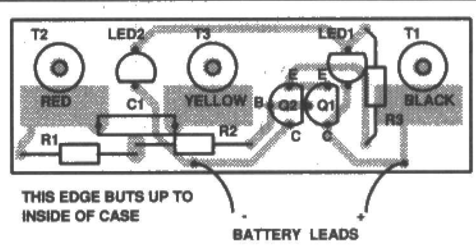


Fig.5 Component overlay

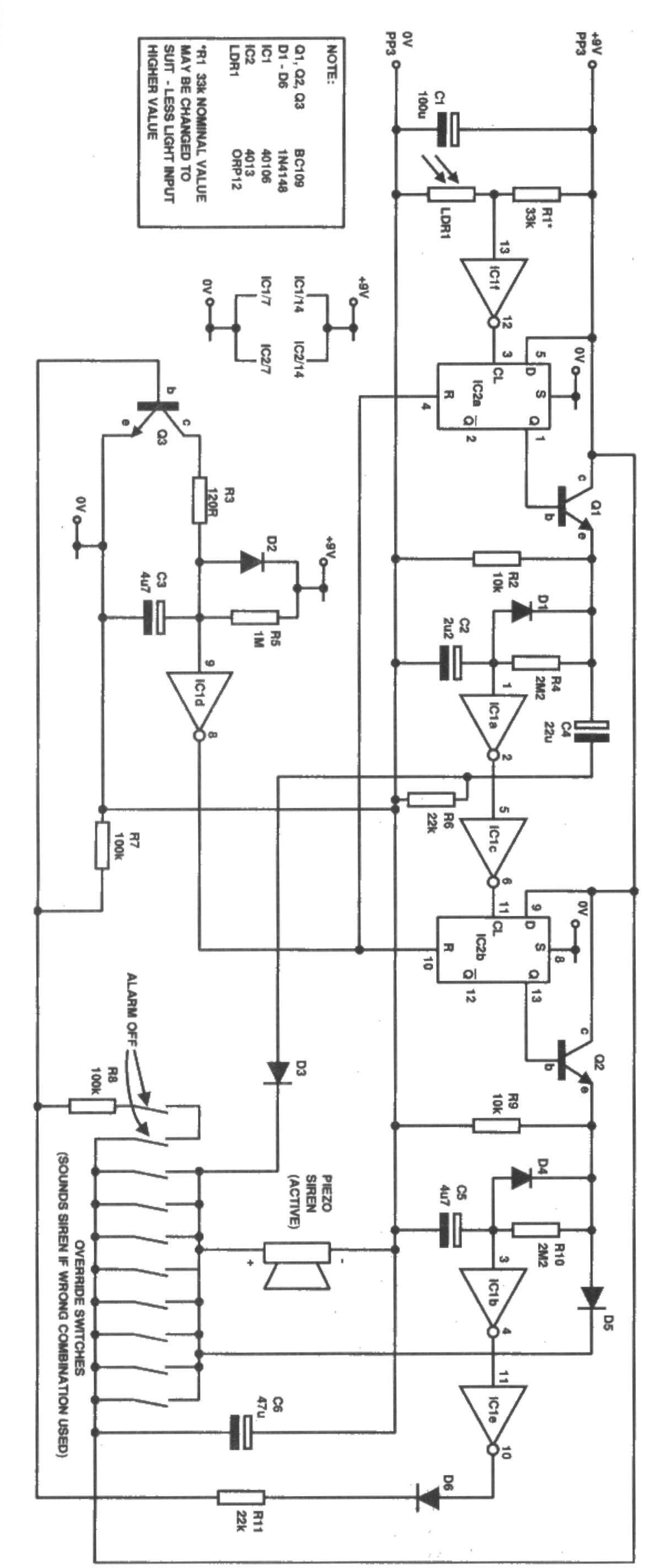


Fig.1 Main circuit diagram

The 'Keepsafe' Alarm

Bob Noyes builds a useful bag alarm

My son always waits until I'm doing something that needs my total concentration to impart bad news -this time I was driving him home in rain and darkness from his swimming training. "Dad, you're not going to believe this but my watch was stolen from my kit bag while I was in the pool". Because I was driving I couldn't react to this bombshell in the way I would have liked to, so instead I set to thinking about how to prevent such a theft happening again. Theft from school/kit bags is rife everywhere as is theft from lockers - there seems little one can do apart from bolting items down (with anti-tamper bolts) or heavily alarming them. It's a sad reflection on society today that almost anything is nickable.

HOW IT WORKS

The sequence of operation is as follows. When the 'keepsafe' is in darkness the value of the sensing light dependent resistor (LDR) is very high, around 1M or so, this means IC1f pin 13, the input to a Schmitt inverter, is high and its output is low. When light falls on the LDR its value drops dramatically, to a few hundred ohms, under bright light although in normal operation a practical value is several thousand ohms, but enough to be seen as a low by the input inverter. Hence a high is presented to the clock of IC2a, a "D" type stat, this clock edge from a low to a high is used to clock the "D" input pin 5, a high (connected to rail), through to the Q pin 1. This will stay a high until reset by a high on the Reset pin 4 (see later).The high on the Q pin 1 turns on Q1 and the emitter will rise to about 0.7 volts below the rail voltage of 9 volts. A pulse is passed through C4 and will give a quick bleep on the sounder. This shows the alarm has been activated and will go off if not de-activated. C2 will start to charge through R4 and when it gets to about 60% of rail (5-6 volts), IC1a pin 1 sees this voltage as a high and inverts this to a low on pin 2. The time taken from the light striking the LDR to the time taken for a "1" to be seen on IC1a pin 1 is the time allowed to de-activate the alarm and hence stop the siren from going off. IC1c is another

Looking around for a solution to the problem I found no practicable deterrent so I decided to design and build one. Several systems on the market operate via body heat like passive infra-red systems; these are fine for protecting a room but not for the confines of swimming bags and where bags are piled on top of each other in a classroom. PIRs aren't completely portable and can't be left near radiators or anywhere there is heat.

The obvious answer was a custom designed unit that would protect a bag or locker as well as alerting a potential thief to the fact that items were alarmed.

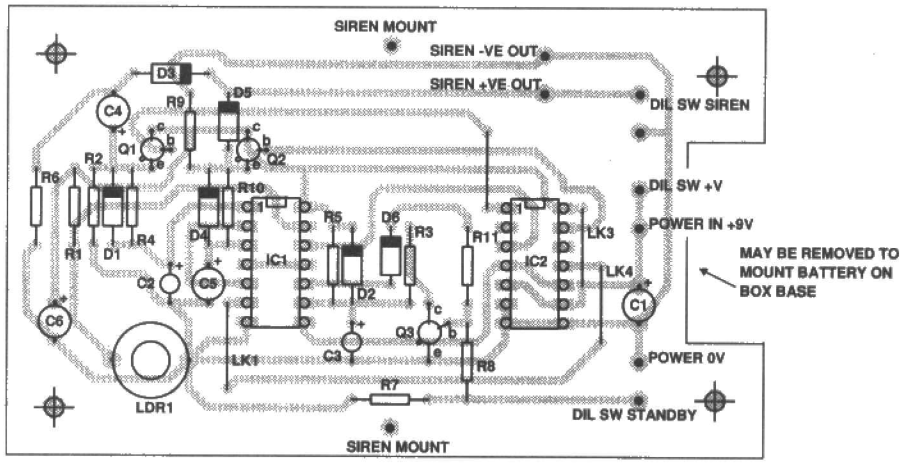
The method of detection was a major problem: tilt switches came to mind first but in changing rooms or bags piled at the side of a football pitch they would prove impracticable because of the constant adding to and taking away of bags from the pile. The logical solution was light. A locked locker and zipped up bag with this alarm inside is the first step to protection - the interiors are in darkness. If opened, light would be allowed in and the alarm activated.

Other problems cropped up such as the de-activation of the alarm: in domestic situations a key or combination must be available - these wouldn't be practical at school or sport and especially with children who tend to lose/forget things at the best of times. A number combination could be used on a keypad but this would add to the cost and electronic complexity. In the end I selected a combination, but of DIL switches: it's easy to customize the code as well as being relatively cheap and easy to install. Should the combination become known it can be easily changed as the switch PCB is small and separate from the main alarm.

Several problems still needed a solution however. To get a loud output i.e. loud enough to attract attention normally requires a large amount of power - short of a car battery or the like - not easily obtainable in a small self contained box. Piezo sounders with the active oscillator built in seemed the solution as they are reasonably loud and require minimal power. Once the sound has been produced within the box it has to come out to be of any use. The sounder is mounted inside the box to prevent damage so holes are necessary for sound emission.

One hole is no good as a towel or books chucked on the top would mask the sound so, to cover all eventualities, two holes on at least three sides of the box were required - the larger the better but if too large they ran the risk of pencils/fingers etc causing damage. The solution was to use holes about 30mm diameter but to cover them with metal mesh on the inside, securely bolted to the case. This had two positives, as well as preventing anyone getting at the sounder it let light in from several sources, an important factor because the alarm would move around in a bag during the course of a day and covering the light detector would disable the alarm. By having large holes on different sides of the box should ensure reliable operation. Since my son has been using the alarm he has had nothing else stolen so we are more than satisfied.

The alarm is always connected to the battery - there isn't an on or off switch in the normal sense (it would be too easy to disable the alarm) but an activate/de-activate switch or



NOTE:
4 X CORNER FIXINGS M3 CLEAR
SIREN MOUNT VIA LONG BOLTS TO HOLD SIREN CLEAR OF COMPONENTS - M3 CLEAR
MOUNT LDR TO POINT TO MAXIMUM LIGHT INPUT

Fig.2 PCB layout

inverter and the low on pin 2 of IC1a causes pin 6 to go high. This low to high level to the clock of IC2b pin 11 is used to clock the D input pin 9, a high (connected to rail), through to the Q output pin 13 of the D type stat.

This high will remain high until reset by a '1' on the reset input pin 10 (see later). This high on the 0 output of IC2b pin 13 is used to turn on Q2, the emitter of which will go to around 0.7 volts below the rail voltage of 9V. This 8.3 volts or so passes through D5 to the siren and will sound until it is reset by a '1' on the reset. This '1' is produced when the combination has been correctly set or the timer times out (see later), When Q2 turns on it also charges C5 through R9. When IC1g pin 3 sees a high. around 60% of rail, the output pin 4 goes low and in turn is inverted by IC1e to produce a high on the output of pin 10. This high will turn on Q3 via 1:10. By turning on T3, C3 is discharged through 1:3 (Just there to prevent the instant discharge of C3 and to protect Q3 from passing very high instant currents).

The discharge of C3 ensures a low on IC1d pin 9, this being another inverter, produces a high on pin 8 which resets IC2a and 2b. This stage also allows a switch on reset when the battery is connected. The alarm is activated by removing the combination on the DIL switches - this combination has kept the alarm in standby condition i.e. reset. This has been achieved by keeping T3 turned on via R7 from the combination switches, so when the combination is removed. Q3 turns off and C3 is now allowed to charge through 1:5 until a '1' is detected on IC1d pin 9. All this time the output of IC1d pin 8 has been high and holding off both stats IC2a and 2b.When C3 has charged and a '1' is seen on IC1d pin 9, pin 8 goes low and the previous reset condition is removed now the alarm is active. Light now falling on the LDR sensor will cause the alarm to bleep once indicating the alarm has been triggered - but there is a delay, governed by R4C2 before the alarm sounds continuously. The alarm sounds for a length of time set by R9C5 before being reset.

It will be noticed that in each case, the timing resistor has a diode across it to allow a discharge path. To discharge the timing capacitors, a 10X resistor completes the path to 0V - this is to ensure that the timing capacitors are discharged before they are required to charge up. It's essential to produce a dependable timing period for each stage.

switches set on a 10-way DIL (or 8-way). See later in the article for combination ideas - making them all identical defeats the object, you don't want everyone to know the sequence.

The electronics uses CMOS ICs that draw such little current in operation that the battery decays faster than the chips used in it. The alarm is normally in the de-activate mode i.e. not functioning and this is done by setting the code on the DIL switch and leaving it set. When you need to use the alarm, the de-activate switch/switches are turned off. This enables the alarm after a time out period of several seconds - ample time to position it in a bag or locker (not forgetting to shut the bag and lock the locker to exclude light).

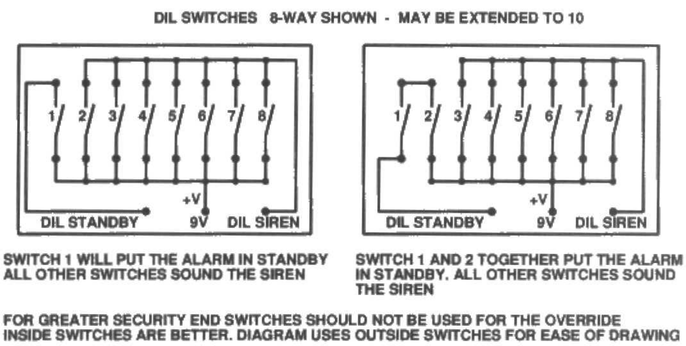


Fig.3 DIL switch arrangement

The alarm will become active after the time out period - around 5 seconds - and any light detected after this time will result in a quick bleep from the sounder alerting you (or a thief) that the alarm has been activated. The main siren will not sound until another 5 or so seconds have elapsed allowing time to set the combination to de-activate the alarm (if it's you going to your own bag/locker). If any of the wrong switches are activated the alarm will sound immediately as they bypass the normal circuit and apply power directly to the siren. Assuming only the correct switch or switches have been turned on the main siren will not sound and the alarm is de-activated. Releasing the de-activate switches will activate the alarm all over again and the same sequence is initiated.

The De-activate Switches

The requirements are simple. Holding the alarm in reset or standby mode, is achieved by the 9V supply being applied to R7 turning on Q3. This is done by using either one or two of the DIL switches - all the others are used to connect the battery directly to the sounder, a deterrent to anyone trying to find the combination by trial or error. Because of these override switches, any wrong switch being made sounds the siren - attracting instant attention. D3 and D6 are required to prevent the 9 volts from getting to the rest of the circuit.

Figure 3 shows an example of one and two switches to de-activate the alarm. End switches have been used for clarity but any of the switches can be used in the same manner.

8-way DIL switches 1 pole, 1 way, are readily available but 10-ways (to increase the possible combinations) are also made and can be found in several small advets in this magazine. There is no upper limit to the number of switches that can be fitted but we've found that as little as eight are ample and fooled everyone trying to switch the alarm off. Two switches are needed to de-activate the alarm, which needn't be next to each other. The small PCB has provision for a 10-way switch so for greater security this area should be individually tracked to prevent all alarms from being the same. To increase the combinations the DIL switch block can be mounted either way round i.e. switches running 1 -8 or 8 - 1. Three possibilities of switch are given on the layout, again a 10-way switch can be incorporated or by leaving a blank at either end an 8-way can be fitted.

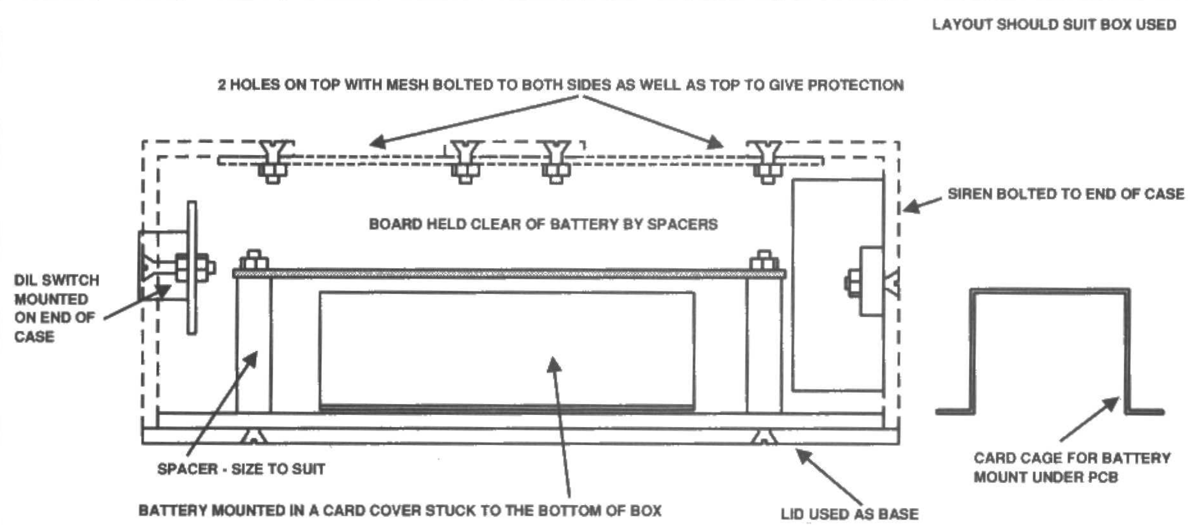


Fig.4 Box constructional details

Both of these models require two switches to be switched to put the alarm in standby. In situations where tampering is unlikely only one switch need be used i.e. keep one of the two switches switched on. The other switch need only be turned on when you want to put the alarm on standby.

For applications where possible tampering may occur, both switches are turned off, hence both need to be turned on to put the alarm on standby.

It will be noticed that several wire links have been used instead of trying to squeeze tracks inbetween others. Also

wide tracks have been used to improve long term reliability as this alarm will receive a lot of vibration in use.

Battery life is totally dependent on usage. Normal use will provide several months of trouble-free operation but if the alarm is sounded several times a day i.e. showing it off, battery life will be shortened accordingly.

One of these units has been used to protect a locker in a local factory where there has been a fair amount of pilfering and just the knowledge that an alarm is in use has prevented any further loss from this particular locker. I feel that several other uses will be found for Keepsafe as changing the various timing periods to suit individual needs is so easy. The value of R1 can be increased to make the alarm more sensitive and the optimum value can be chosen by trial and error. Increasing the value means the alarm requires less light to activate it.

The Box

Several boxes were tried in the prototypes but I found the best to be a box from Electromail. However, it is the most expensive. Although slightly larger, a Maplin box was much cheaper (about half the price) but still satisfactory. The mesh used was a grill used to protect air cooling fans although speaker mesh would work just as well. Care must be taken that as well as letting sound out it must let light in too. Proper fan guards could be used as they have bolt holes pre-formed and are designed to keep fingers out but, as at least five and up to seven are required and being slightly dearer, this option would work out to be more expensive. The sounder can be mounted above the PCB. Two holes are provided and the sounder sits on either spacers or long bolts with a nut positioned so that the siren is not touching any of the components on the PCB. The mounting on top of the board is used with the Electromail/RS type box but if you're using the Maplin type box the sounder is mounted at the end of it, next to the PCB. Care must be taken when mounting the siren as the sound comes out of the small hole on the top -if this is covered or is mounted very near a solid object i.e. battery or the side of the box, then the volume is reduced.

When using a smaller box (120mm x 65mm x 65mm), part of the end of the PCB is removed to allow the battery to stand up. This is shown by shading on the PCB drawing and is marked on the back side of the PCB. Two versions of layout are shown in the photographs but in the end, the layout depends on the type of box used.

PARTS LIST

RESISTORS

R1	33k
R2,9	10k
R3	120R
R4,10	2M2
R5	1M
R6,11	22k
R7,8	100k

CAPACITORS

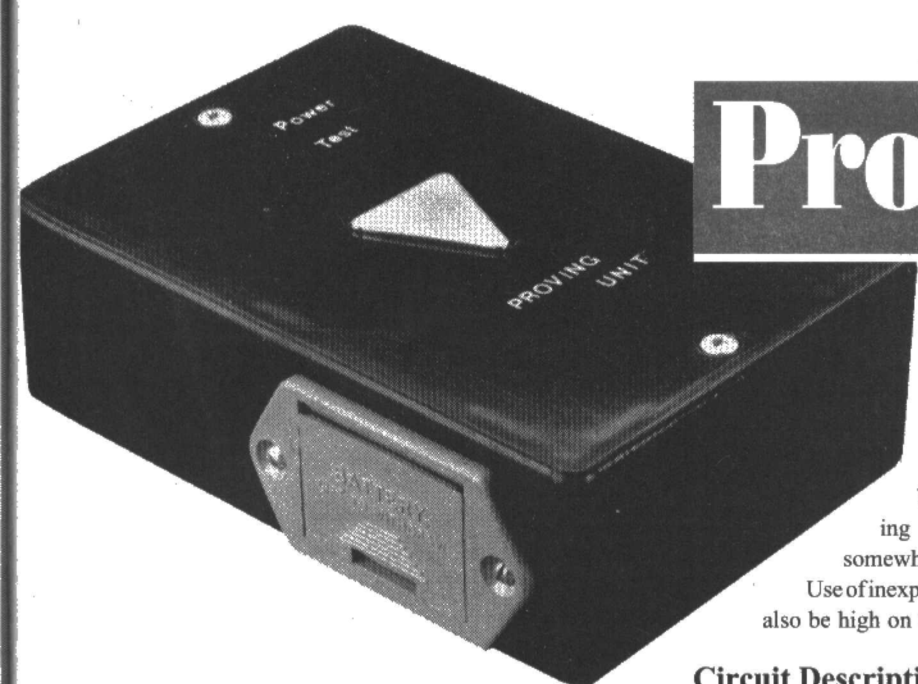
C1	100u/16V
C2	2u2 Tant 16V
C3,5	4u7 Tant 16V
C4	22u/16V
C6	47u/16V

SEMICONDUCTORS

IC1	40106
IC2	4013
Q1,2,3	BC109
D1-6	1N4148

MISCELLANEOUS

LDR 1 ORP12
Siren with leads 12V (Maplin FK84F)
14 pin IC sockets
Box (Maplin KC 90X or Electromail No. 583-101)
PP3 Battery
DIL Switches 8way Maplin No. XX 27E or 10way No.FV 45Y



Proving Unit

By Mark Daniels

Live Testers in the guise of an electrical screwdriver with a neon in the handle are popular amongst electricians involved in working with mains electricity. They are frequently used to check that a circuit is isolated and therefore safe to work on. Unfortunately a faulty live tester gives the same indication as does an isolated circuit leading to the potentially lethal situation of work being carried out on a live installation.

A wise electrician, who wants to live to collect his pension, will always make sure that his live tester is working both before and after checking the potential on any circuit. However, if the power is supposedly switched off there is not normally a live terminal available for this purpose, but the wise electrician does not panic; he carries his own live source with him in the form of a proving unit.

This pocket sized device is capable of producing a high voltage, from its internal battery supply, for the specific purpose of checking live testers.

Design Criteria

A small low power unit capable of producing a hundred or so volts on demand while running from readily available batteries would fit the requirements of the average electrician. A 90 volt HT battery, intended for valve radios would seem to be the obvious choice, but one look at the price and a quick discussion with the bank manager will put paid to that simple idea.

Back at the drawing board a few simple ideas began to emerge and a decision to use a small inverter was taken. Recalling hazy memories of A level physics lessons revealed that a discharge in neon gas would take place with either polarity of supply (unlike LEDs) and, better still, that an AC source of any frequency could also be used.

At this point the design requirements became clear: a small inverter running from a 6 to 12 volt source with an output in the region of 90 to 200 volts at any frequency you care to mention!

Applying a little common sense narrows this down to a 9 volt PP3 battery, an output voltage approaching the higher figure and a frequency somewhere just above the audio spectrum. Use of inexpensive components throughout would also be high on the list of priorities.

Circuit Description

The circuit chosen is extremely simple and is based around the ubiquitous 555 timer IC and is shown in Figure 1.

IC1, a 555, is used here in its astable mode to produce a square wave of almost equal mark-space ratio at a frequency of approximately 28kHz, set by resistors, R1, R2 and capacitor, C2.

The output of IC1, at pin 3, is applied to the primary of a small high frequency transformer, T1 via a DC blocking capacitor, C4. The primary winding of T1 has a small amount of inductance and, in conjunction with C4, forms a series resonant circuit, having a resonant frequency of approximately 23kHz under no-load conditions.

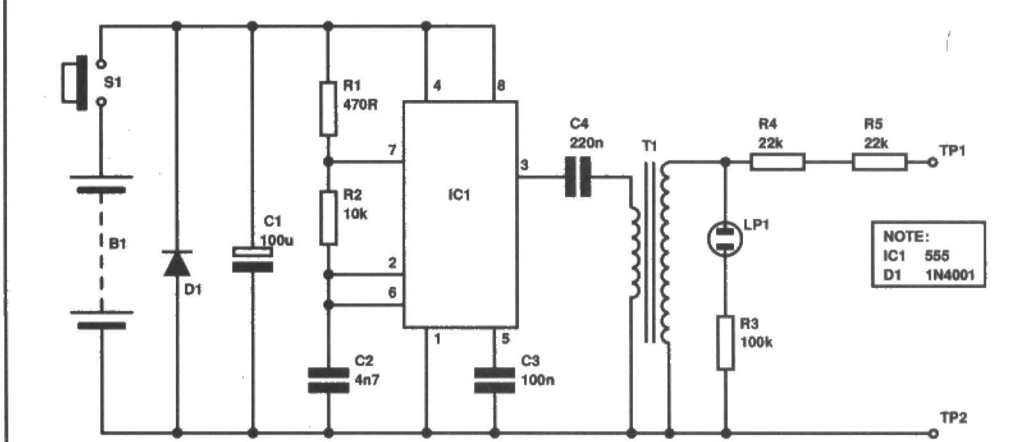


Fig.1 Complete circuit diagram of Proving Unit

The transformer is wound with a primary to secondary ratio of 1:21, so steps the voltage on its primary up to a much higher value across the secondary. The output of a 555 running from a 9 volt supply is only about 3 volts RMS and applied directly to the transformer primary would produce an output of 3x21, or 63 volts, which is insufficient to strike a neon requiring a minimum of 80 volts.

However, the transformer primary forms part of a resonant circuit as stated above and we can expect a resonant rise in voltage across both components in this circuit. The transformer experiences this rise as its primary voltage and steps it up to around 150 to 200 volts which is adequate for our

purposes.

One side of the secondary winding is connected to the battery negative terminal and a metal touch pad on the outside of the case. The 'hot' side of the output is current limited by series resistors, R4 and R5.

A neon, LP1, connected across the output in series with R3 indicates when a high voltage is present on the output of the unit.

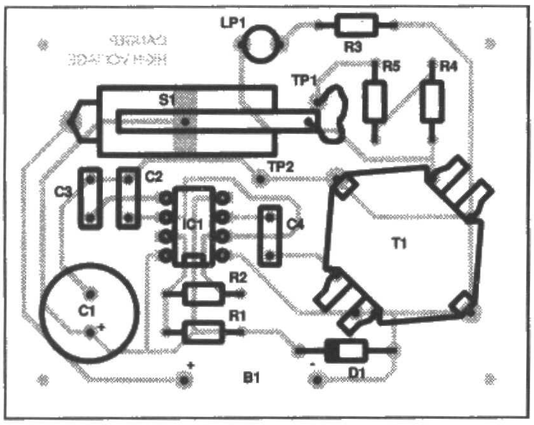


Fig.2 Component overlay

PCB Assembly

The majority of the components are assembled on a small single-sided printed circuit board. The component overlay for this being provided in Figure 2. Before assembling any of the components to the PCB it will be necessary to check that the mounting hole and slot for the micro-switch, SW1 are suitably placed and sized. The normally-open connecting tag on the underside of the switch will need straightenning before it may be fitted.

Fit the resistors, capacitors, IC socket and diode to the PCB and solder them in position. Fit PCB pins to the board for all external connections, as this will make final interwiring very much easier.

Do NOT be tempted to replace R4 and R5 with a single resistor of higher value. Two resistors have been specified for your safety! If one of these resistors fails to a short circuit then there will still be sufficient resistance in circuit to protect the operator from electric shock.

Cut the operating lever of the switch down to approximately 25mm and drill a 2mm diameter hole in the end of it for a small solder tag to which a short lead is attached for connection to the PCB The switch assembly may then be installed and soldered, a short piece of 24SWG tinned copper wire being used for the connection to the common terminal.

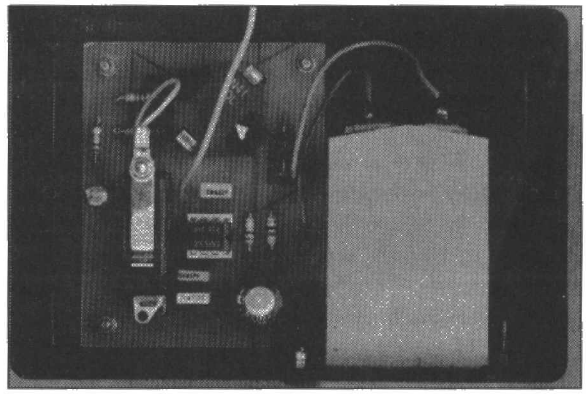
LP1, the wire ended neon lamp should be mounted to stand just above the switch operating lever.

Transformer Winding

The transformer consists of just two windings wound on an RM8 potcore; the high voltage secondary and the much lower voltage primary.

Referring to Figure 3, random wind (i.e. not in precise layers) 150 turns of 36SWG enamelled copper wire, starting at pin 3 and finishing at pin 4. Keep the winding neat and try not to let turns from the upper layers drop into lower layers, as this will place high stresses on the very thin insulation.

If there is any possibility at all that the winding may be a few turns short, due to a counting error, add an extra 10 or 15 turns for good measure. Secure the finish end of the winding to pin 4 and wrap several layers of PTFE pipe thread tape over the coil to insulate it.



The primary is wound between pins 2 and 5 on top of the secondary and consists of just 7 turns of 24SWG enamelled copper wire in two layers, spread evenly across the width of the former. Insulate as above and fit the two halves of the core, securing them with the clamps provided.

The relative winding direction of the two coils is unimportant as long as all turns for each are unidirectional.

Use an insulation tester, or a multimeter set to a high ohms range, to check the insulation between the two windings, and between each winding and the core. The continuity of the windings may also be checked using a low ohms range before the completed transformer is fitted to the board.

Assembly to Case

Because of the high voltages present within this unit it is important that consideration is given to the aspect of safety when assembling.

It is recommended that careful consideration be given to the choice of enclosure for this project, and a plastic box with integral battery compartment is suggested. Alternatively, a PP3 battery drawer may be fitted to any suitably sized plastic enclosure as in the prototype.

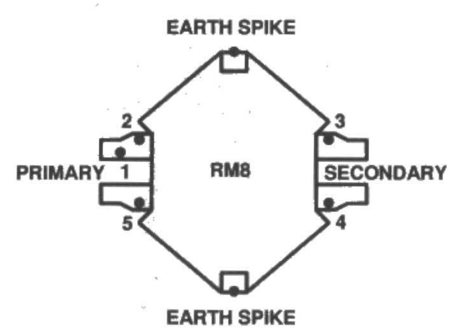


Fig.3 Pot core details

Mount the PCB in the bottom part of the case on PCB pillars.

Drill three small holes in the case lid, one each to line up with the neon and micro-switch operating lever, and a third one for the single touch pad.

Fit the touch pad, placing a solder tag under the securing nut and solder a short length of insulated wire to the tag. Make all of the electrical connections to the PCB in accordance with the overlay diagram of Figure2 and assemble the lid to the case.

Fit a PP3 9 volt battery and, using a screwdriver with an insulated handle and shaft, operate the micro-switch through

the appropriate hole. With any luck the neon should glow brightly, indicating the prescence of a high voltage across the secondary of T1.

The final test is with a mains test screwdriver. Operate the micro-switch with the tip of the screwdriver, whilst simultaneously touching the metal contact at the end of the screwdriver handle and the touch pad on the Proving Unit. The neons in both the screwdriver and the Proving Unit should illuminate.

Because of the high voltages involved in this device, testing should only be carried out with the unit completely assembled. If fault finding becomes necessary take great care when checking the high voltage side. Remember, when connecting oscilloscopes, and the like, that one side of the secondary is connected to battery negative.

The output current of the circuit is very limited, but it can still give an unpleasent shock, when least expected.

Fault Finding

The circuit is very simple and should present few problems if constructed as described.

If the device fails to work check for the obvious first, such as components fitted in the wrong positions or with incorrect polarity. Also, check for solder bridges, particularly around IC1.

The transformer may cause problems if insufficient care is taken whilst winding the high voltage secondary. Check, also, that the primary and secondary are connected to the correct pins as shown in Figure 2, remembering that this shows the underside view of the transformer.

If possible measure the output voltage from the transformer, with an oscilloscope or high impedence AF voltmeter. A minimum of 100 Volts is required to ensure satisfactory operation, and in practice 150 to 200 volts should appear across the output.

PARTS LIST

RESISTORS

R1 470R
R2 10k
R3 100k
R4 22k
R5 22k

CAPACITORS

C1 100µ/25V Radial Elec
C2 4n7 Boxed Polyester, 5mm pitch
C3 100n Boxed Polyester, 5mm pitch
C4 220n Boxed Polyester, 5mm pitch

SEMICONDUCTORS

D1 1N4001
IC1 555

MISCELLANEOUS

T1 RM8 Potcore (B65811-JR41), Bobbin (B65812-J1005D1), Clamps (B65812-A2203) 2 off
B1 PP3 9 Volt Battery
LP1 Wire Ended 90 Volt Neon S1
Lever Actuated Micro-Switch Small Plastic Box with Integral Battery Compartment (Approx. 110x80x25); PCB Pins (4 off); Triangular Touch Pad.

BUYLINES

The parts for T1 were purchased from Electrovalue Ltd. Tel: (0784) 433603. The touch pad is a Maplin part. The microswitch and neon were purchased from JPG Electronics Tel: (0246) 211202.

1

Paul Clements provides details of an infra-red astronomical telescope control system.

Infra Guide

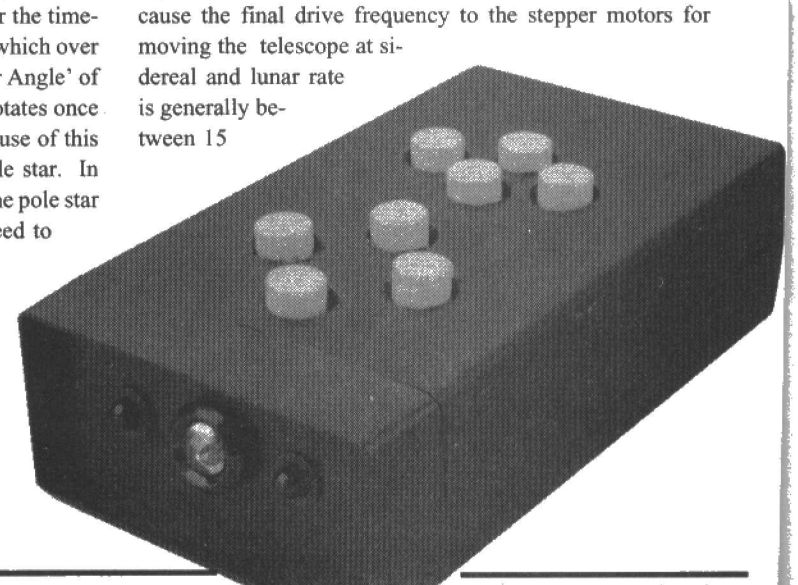
FEATURES

Cordless operation - No wire from handset to trip over in the dark
Setting circle illuminators
Dual speed control of both axes of an equatorially mounted telescope
Can be wired to suit any motor and gearbox combination
Sufficient torque to control reflecting telescopes up to 12 inches in diameter or refractors up to 6 inches in diameter
Built in, efficient red torch in handset
Sidereal and Lunar tracking rates
External Interface Connector (For either controlling the unit by a computer or for autoguiding using a photodiode array on the finder scope)

The Infra-guide is an electronic drive corrector which allows an equatorially mounted astronomical telescope to track the stars, sun, planets and moon as they appear to move around the pole star due to the rotation of the earth.

For the beginner, here is a basic explanation of how an equatorial mounting functions: Each star has its own set of co-ordinates in the sky. These are known as Right Ascension and Declination. To all intents and purposes the right ascension and declination of each star remain fixed, for the time-being if we ignore the proper motion of the stars, which over a period of many years is infinitesimal. The 'Hour Angle' of a star, however, changes as the earth rotates (it rotates once in 23 hours 56 minutes and 4 seconds) and because of this rotation the stars *appear* to move around the pole star. In order to track any star's apparent motion around the pole star (to follow it as its Hour Angle changes), we need to point the telescope at the desired star and swivel it around the pole star exactly once in 23 hours 56 minutes and 4 seconds. An equatorial mounting can accomplish this by virtue of two shafts at right-angles to one another, one of which points to the north celestial pole, which as good fortune would have it, lies very close to the pole star. If we attach a motor/gearbox assembly to the shaft which points to the north celestial pole (the 'Right Ascension' or 'R.A' shaft, which follows the Hour Angle of the star), we can turn the shaft at exactly the right rate to keep a star centralised in the field of view of the telescope. With forward and reverse actions on the Right Ascension motor, we can slew the telescope to stars either side of the one being observed, or use the forward/ reverse functions for accurate centralising of a star in the field of view. By having a motor/gearbox assembly on the shaft at right angles to the right ascension shaft (the 'Declination' or 'Dec' shaft, we can achieve adjustment forward and reverse perpendicular to the right ascension shaft. Thus adjustment in four directions at right angles to each other is achieved and the Infra-Guide is designed to do just this.

The infra guide has been developed to overcome the one main shortcoming of all telescope drive systems currently on the market - the hard-wired hand control unit, which is a common source of irritation amongst amateur astronomers for being so easy to trip over in the middle of the night. The system is entirely digital in operation, and is designed around the L297 stepper motor driver ICs, using a 3.2768MHz crystal and Johnson ring counter/divider as the basis. Because the final drive frequency to the stepper motors for moving the telescope at sidereal and lunar rate is generally between 15



PROJECT

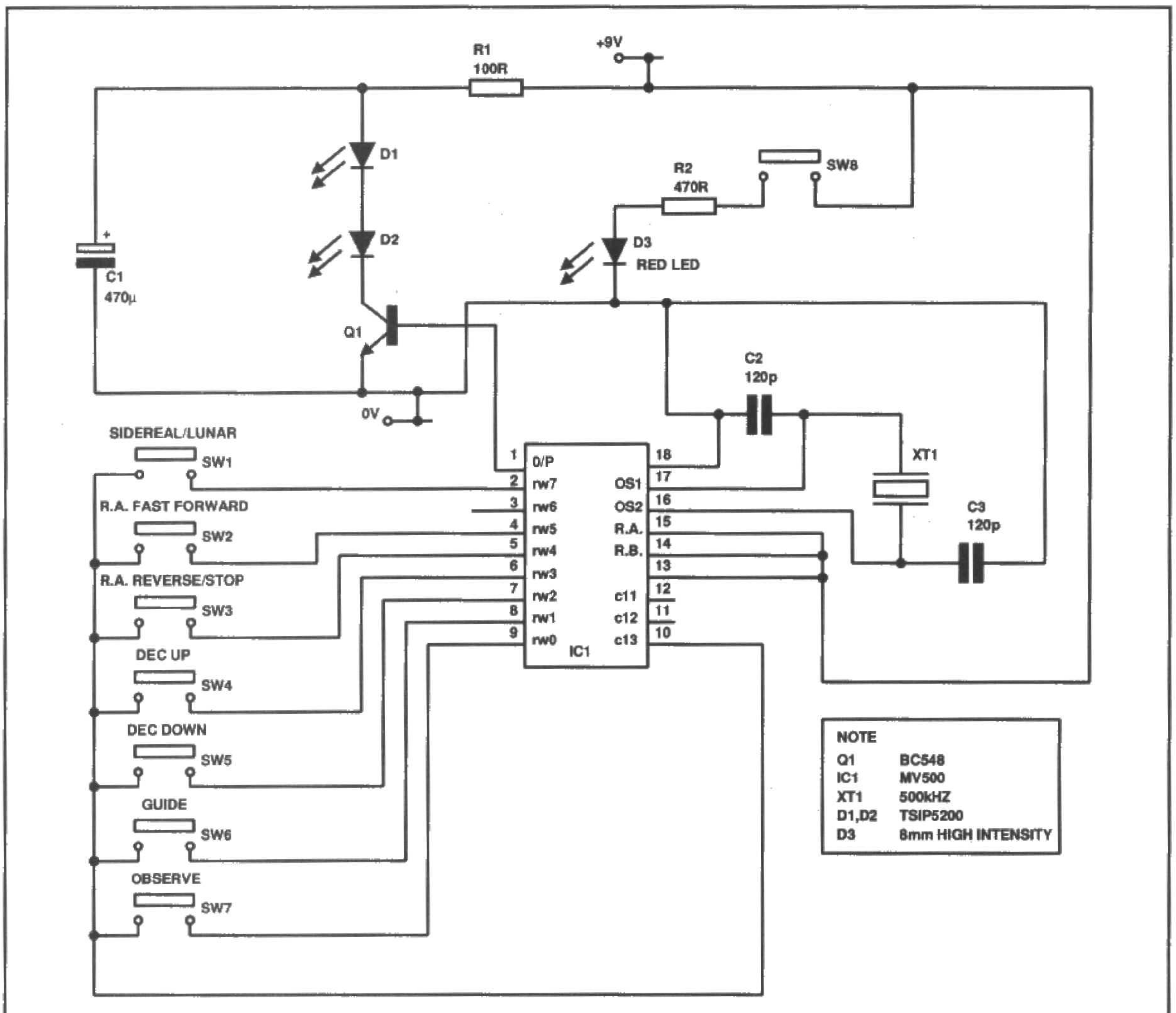


Fig.1 Circuit diagram of Infra-red transmitter

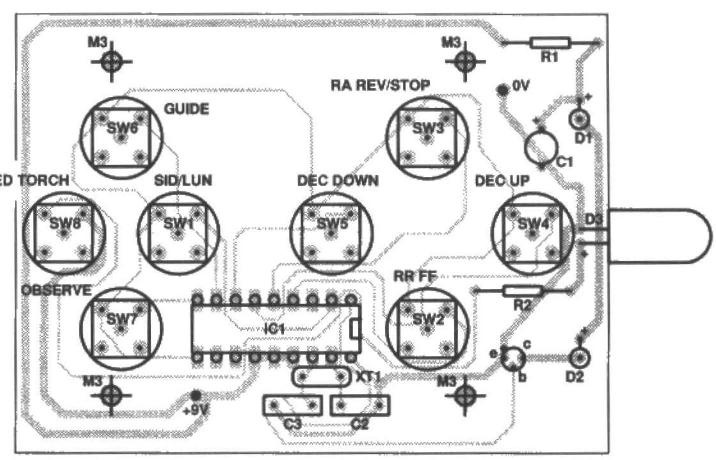


Fig.2 Component overlay of transmitter

and 30Hz, the divide ratio from the 3.2MHz crystal is of the order of 160000, achieving an accuracy of 3 seconds of sidereal time, worst case, per day. This is more than adequate for both visual and photographic astronomy. The 'step angle', which is the angular distance moved by the telescope for each step of the stepper motor, can be set to approximately 0.6 seconds of an arc per step, equivalent to the resolution of a 12 inch telescope main mirror or lens, and will generally not be discernable due to the inertia of the telescope and mounting. An advantage of the Infra-guide is that it can be wired to drive any gearing arrangement and thus effectively any equatorially mounted telescope.

All functions found on conventional drive systems are present on the Infra Guide, together with a few more.

Infra-guide Functions

Firstly, looking at the keys on the handset, these are:

1) SIDEREAL/LUNAR

Toggles between sidereal and lunar guiding rates each time the key is pressed.

2) DEC UP

Moves the telescope in declination.

3) DEC DOWN

Moves the telescope in declination but in the opposite direction to DEC UP.

4) R A FORWARD

Moves the telescope forwards in right ascension.

5) R A REVERSE/R A STOP

Moves the telescope in reverse direction in right ascension or stops the right ascension motor, depending on whether the system is in GUIDE or OBSERVE mode (see below).

6) GUIDE

When using the telescope for astrophotography, it is necessary to keep the object being photographed in precisely the same position in the field of view for up to several hours at a time depending on the object(s) being photographed. If for any reason the object moves from its position, e.g. due to atmospheric refraction or misalignment of the polar axis of

the telescope stand, it is necessary to bring the object back to the desired position as quickly, accurately but as gently as possible. In order to accomplish this, the Guide mode key is pressed. This latches the R A Forward, Dec up and Dec down keys to slew the telescope at twice sidereal rate. As the right ascension motor is geared down before feeding the polar axis shaft of the telescope, there will be backlash on the gears. Also, if the telescope were reversed in right ascension in order to re-centre the desired object on a photographic plate, the backlash would have to take up after the R A Reverse key were released. This causes smearing or "trailing" on the photographic plate. In order to avoid this happening, the RA motor is stopped when the Infra Guide is latched into Guide mode. This also has the advantage that the apparent slewing rate obtained by pressing the R A Forward or R A Reverse keys, in Guide mode, is the same.

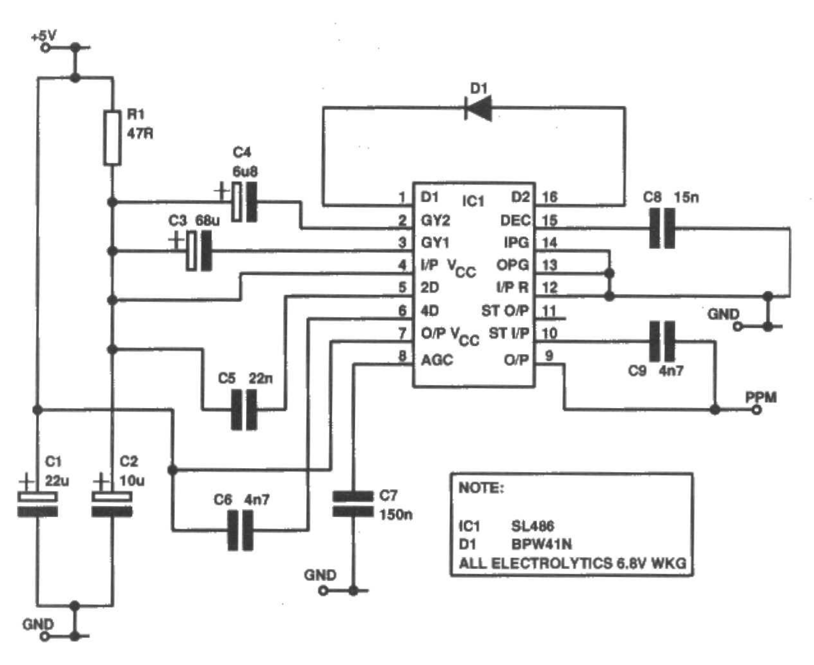


Fig.3 Circuit of Infra-red receiver module

7) OBSERVE

This latches the R A Forward, R A Reverse, Dec up and Dec down keys to slew the telescope at up to 12 times sidereal rate, depending on how the constructor has decided to wire the system. This will allow an object to be easily and quickly centred in the field of view. When any of the direction keys (R A Forward, R A Reverse, Dec up, Dec down) are released, the system reverts to the mode in which it was previously (Sidereal or Lunar).

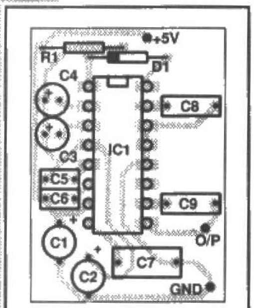


Fig.4 Component overlay of receiver module

Design Considerations And Conclusions

The majority of telescope gearing system have wormwheels to drive the right ascension and declination shafts. In order to determine the drive frequency to the L297 stepper driver ICs, the number of teeth on the wormwheel must be counted.

The formula for calculating the drive frequency is as follows:

a) Sidereal drive frequency = (N x R)/448.77083

b) Lunar drive frequency = (N x R)/465.80625

Where:

N = number of teeth on the wormwheel

R = reduction ratio of the gearbox (25, 50, 125 or 250, see below)

There are a choice of gearboxes available: 25:1, 50:1, 125:1, 250:1.

It is recommended that the following combinations of motor/gearbox are used:

WORMWHEEL TOOTHCOUNT	GEARBOX RATIO
144-199	125:1
200-325	125:1
325-649	50:1
650-800	25:1

In order that the stepper motor steps are *not* seen through the telescope, the minimum drive frequency required = 30Hz, and in order that the maximum fast forward/reversing speeds be obtainable (approx 15 times sidereal), the maximum drive frequency for sidereal rate should not exceed 80Hz. Therefore a gearbox must be chosen that will need between these two values to drive the telescope.

NOTE: The above frequencies are *not* the frequencies fed directly to the stepper motor driver ICs, but the drive frequencies present at the reset pins of the 4017 divider chain, and consist of a series of very fast reset pulses, which will probably *not* be visible on an oscilloscope because of their speed. The actual frequencies fed to the L297 stepper motor driver ICs are half the value of the above frequencies and consist of 1:1 mark space ratio squarewaves. The drive frequency fed to the right ascension stepper motor driver IC is half the frequency present at the output of the 4017 divider chain and is a 1:1 mark:space ratio square wave.

Drive Calculations For R A Forward/ Reverse And Dec Forward/Reverse

Firstly we require the following details:

R A Forward/Reverse, Observe
= 12 x Sidereal drive frequency

R A Forward, Guide
= 2 x Sidereal drive frequency

Dec Forward/Reverse, Observe
= 12 x Sidereal frequency

Dec Forward/Reverse, Guide
= 2 x Sidereal frequency

Here is a worked example:

The wormwheel has 440 teeth and we want to keep the sidereal drive frequency between 30 and 80Hz; Choose 45Hz, arbitrarily sidereal drive frequency

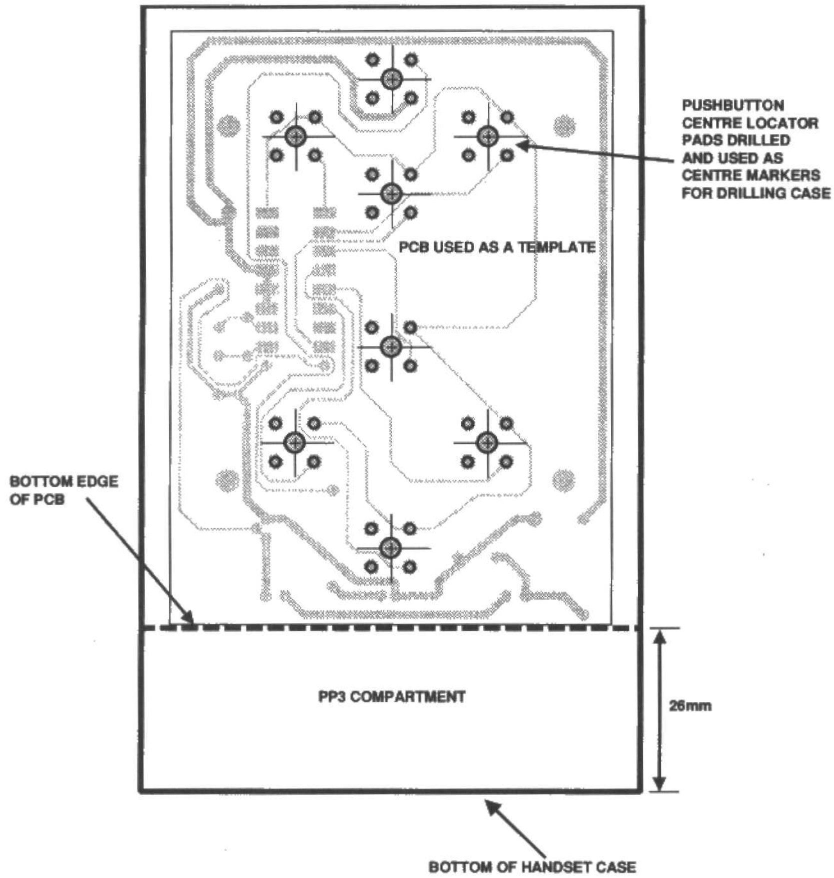


Fig.5 Details of push-button positioning within handset

= (N x R)/448.77083 if N=440

Rearranging:

Gearbox ratio required (R) = (448.77083 x 45)/440
= 45.897

This ratio cannot be obtained, and the closest ratio obtainable = 50:1 (this is recommended in the table above)

Sidereal drive frequency = (N x R)/448.77083
as N=440 and R=50

Required sidereal drive frequency
=(440 x 50)/448.77083Hz
= 49.022794Hz

Lunar drive frequency = (N x R)/465.80625
=(440 x 50)/465.80625
=47.22994Hz

R A Forward/Reverse, Observe = 12 x 49.022794Hz
= 588 Hz approx

R A Forward, Guide = 2 x 49.022794Hz
= 98 Hz approx

The final two frequencies are not critical.

The drive frequencies are individually set for each telescope, by hardwiring the divider outputs from the ICs: IC3, IC8, IC12, IC14 and IC16. The highest divide ratio from the divider chain is 99999. IC3 divides by up to 9, IC8 by up to 90, IC12 by up to 900, IC14 by up to 9000 and IC16 by up to 90000. The divide outputs from each IC are brought out to pins which are labelled on the PCB overlay and are adjacent to each 4017 divider IC. The formula for divide calculations is 3276800/drive frequency (the drive frequencies in each case are calculated as above)

WORKED EXAMPLE:

See Figure 5,5a and below. The required drive frequency for sidereal as calculated above, for sidereal rate, is 49.022794Hz. We are dividing down from a 3276800Hz crystal so the required divide ratio for this frequency = 3276800/49.022794
= 66842.375

The closest divide ratio we can obtain is 66842, which will turn the telescope round once in 23.93431 hours or 23 hours 56 minutes 3.5 seconds. For this divide ratio, we connect the following inputs to the 'X' inputs of the 'SIDEREAL' AND gate (IC7) inputs:

count '6' from IC16 (pin 5)
count '6' from IC14 (pin 5)
count '8' from IC12 (pin 9)
count '4' from IC8 (pin 10)
count '2' from IC3 (pin 4)

For the same wormwheel, as calculated above for LUNAR rate, the required drive frequency = 47.22994Hz
and thus the divide ratio required is = 3276800/47.22994
=69379.72.

The nearest divide ratio obainable is:
69380.

For this divide ratio, we connect the following inputs to the 'Y' INPUTS of the 'LUNAR' AND gate (IC4):

count '6' from IC16 (pin 5)
count '9' from IC14 (pin 11)
count '3' from IC12 (pin 7)
count '8' from IC8 (pin 9)
count '0' from IC3 (pin 3)

For the same wormwheel for GUIDE drive frequency (twice sidereal rate) the

divide ratio we require = 3276800/98
= 33436.7 and this is not critical. The nearest divide ratio we can obtain is 33437, which means connecting up the following pins:
count '3' from IC16 (pin 7)
count '3' from IC14 (pin 7)
count '4' from IC12 (pin 10)
count '3' from IC8 (pin 7)
count '7' from IC3 (pin 6)

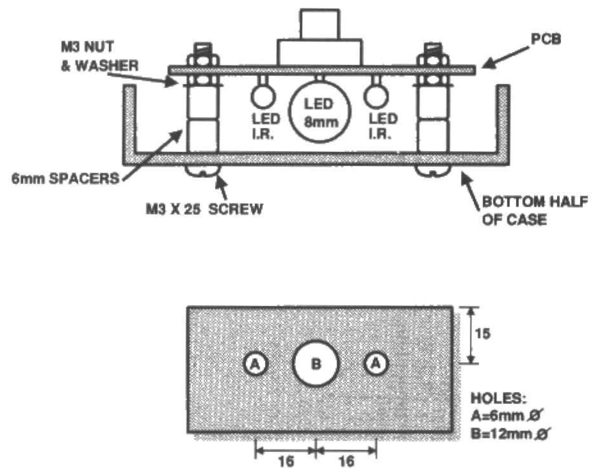


Fig.6 LED arrangement within handset (front view)

These are the pins connected to the inputs of the 'Z' inputs of the 'GUIDE' 'AND' gate IC13. For the OBSERVE drive frequency (12 times sidereal rate), the divide ratio required = 3276800/588
=5572.7 (USE 5573)
This divide ratio is not critical. Nearest divide ratio obtainable = 4369
i.e count '5' from IC14 (pin 10)
count '5' from IC12 (pin 7)
count '7' from IC8 (pin 5)
count '3' from IC3 (pin 11)
These are the pins connected to the 'W' inputs of the 'OBSERVE' 'AND' gate IC10. No outputs from IC16 are connected to the 'OBSERVE' AND gate in this case. This means that one 'W' input pin of the 'OBSERVE' AND gate is left unconnected; CONNECT THIS PIN TO +5V.

NOTE: All unused pins on the inputs to the 'AND' gates must be connected to +5V

DECLINATION DRIVE CONNECTIONS

There are only two connections to make for the declination axis. These should be set for the following combinations of wormwheels and gearboxes: DECLINATION RECOMMENDED CONNECT PINS 'A1' AND "A2" are shown below.

WORMWHEEL TOOTHCOUNT	GEARBOX REDUCTION RATIO	A1 TO IC23 COUNT	A2 TO IC23 COUNT
144-199	125:1	"3"	"9"
200-249	125:1	"2"	"8"
250-299	125:1	"2"	"7"
300-399	50:1	"3"	"9"
400-499	50:1	"3"	"9"
500-649	50:1	"3"	"9"
650-699	25:1	"6"	"9"

In order to wire the system to the user's individual requirements then, it is necessary to make 20 connections from the 'AND' gates to the counter outputs for right ascension and two connections for declination. Step size calculations: Step size as seen through the telescope = 13500/(N x R) ARC SECONDS. So for a wormwheel toothcount of 600 teeth and a gearbox reduction of 25:1, step size = 13500/(600 x 25) = 0.9 arc seconds per step. In reality this will not be seen due to the inertia of the telescope and mounting. Connections to the external interface: If the user has autoguiding facilities in the form of a photodiode array on the finder or guide scope, the outputs from the phototdiode detector array can be amplified and used to trigger the Infra Guide to slew the telescope in right ascension and declination back to the desired guide star, should it drift away from the centre of view. This is accomplished by having four control lines on the rear of the Infra Guide enclosure. These control lines are activated by 5V logic with maximum 10k drive impedance, as shown in the following table:

CONTROL LINES

G	H	I	P	FUNCTION ACTIVATED
0	0	0	0	OBSERVE (LATCHED)
0	0	1	0	GUIDE (LATCHED)
0	1	0	0	DEC DOWN
0	1	1	0	DEC UP
1	0	0	0	R.A REVERSE/STOP in guide mode
1	0	1	0	R.A FAST FORWARD
1	1	1	0	SIDEREAL/LUNAR (TOGGLE)
X	X	X	HIGH	PRIORITY TO HANDSET IMPEDANCE
X	X	X	1	NOT ALLOWED X = DON'T CARE

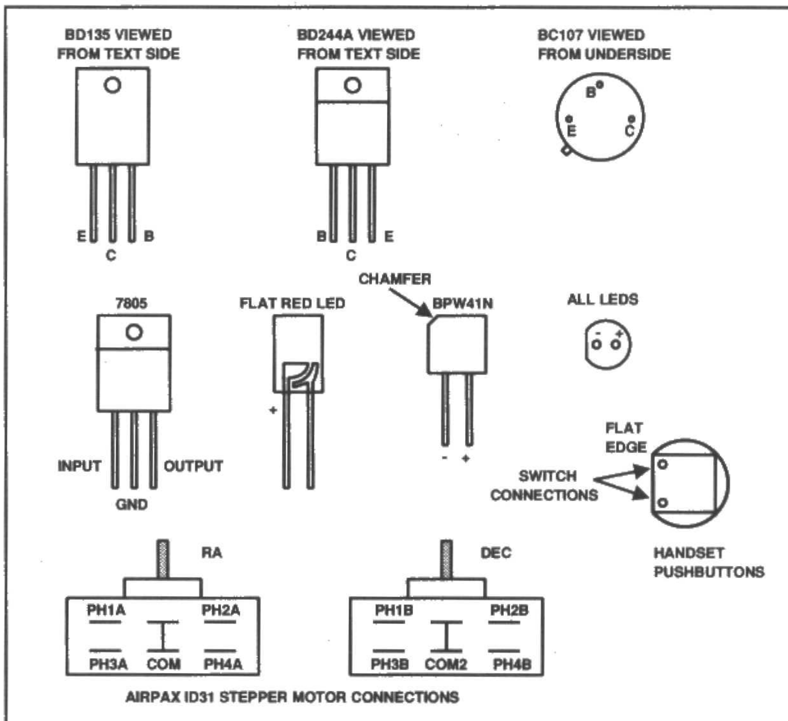


Fig.7 Details of pin-outs for semiconductors and stepper motor

Construction

Construction of the main control box along with the circuit diagram and component overlay will appear next month meanwhile, we can begin with the handset.

Before connecting any of the components, use the PCB pushbutton centre holes as a template for drilling the case; the PCB can be taped to the case as shown in Figure 1 and 1mm pilot holes drilled in the case for the pushbuttons.

Mount the LED's on the underside of the PCB leaving

enough lead length for the top of the LED's to penetrate through the front of the case.

All other components can now be put in place, the case drilled and the battery connected. The PCB should be mounted on stand off pillars to allow the tops of the pushbuttons to clear the top of the case. If necessary, the pillar height may be built up with two 6mm spacers and M3 nut and washer (see Figure 4).

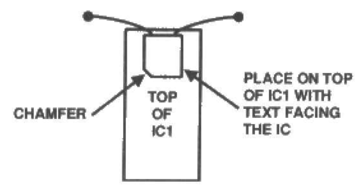


Fig.8 Diode positioning over IC1

NOTE:There is a flat on the pushbutton and the switch contacts are either side of the flat.

When drilling the clearance holes for the pushbuttons, it was found that gripping the case firmly in the jaws of a large vice and having the drill speed on a fast setting produced the cleanest cut.

The infra red receiver preamplifier can now be constructed.

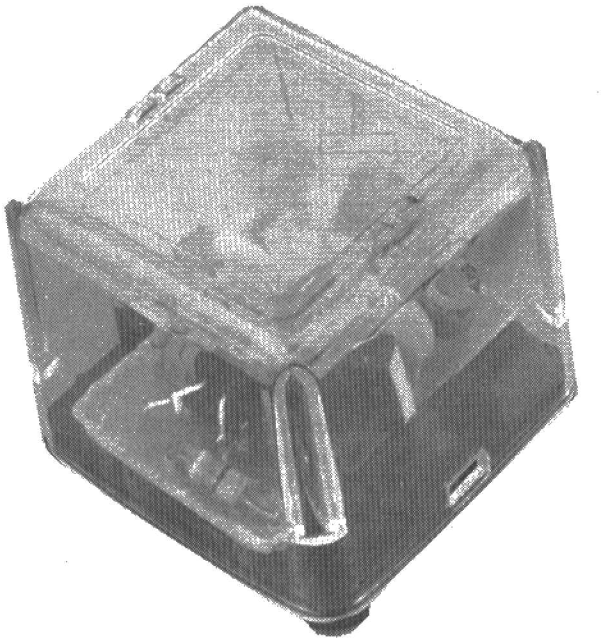
Mount D1 on top of IC1 with the text of the diode facing towards the IC, as shown in Figure 3.

Mounting The Infra-red Pre-amplifier

The infra red preamplifier should be mounted inside a clear perspex enclosure such that the infra red receiver diode may be activated by the handset from as wide an angle as possible. A suitable enclosure is Farnell order code mp4511.

This has a 'valve' type base which can be removed using a junior hacksaw and the formed pins can be removed by tugging with a large pair of pliers.

For easy attachment and removal from the telescope, it is recommended that 'velcro' type fasteners be employed.



Remote Control Handset Enclosure

This is pilot drilled using the handset PCB as a template as previously stated and as shown in Figure.1. 11mm Clearance holes for the pushbuttons should then be drilled. Drill/cut out the front panel as detailed in Figure.4 and mount the PCB with spacers as shown.

PARTS LIST

PREAMPLIFIER PCB

RESISTORS

R1 47R

CAPACITORS

C1 22u/6.3V Elect
C2 10u/6.3V Elect
C3 68u/6.3V Elect
C4 6u8/6.3V Elect
C5 22n
C6,9 4n7
C7 150n
C8 15n

SEMICONDUCTORS

D1 BPW41N SEE BUYLINES
IC1 SL486

MISCELLANEOUS

CLEAR PERSPEX MOUNTING ENCLOSURE

HANDSET PARTS LIST

RESISTORS

R1 100R
R2 470R

CAPACITORS

C1 470u/16V miniature electrolytic
C2,C3 120p

SEMICONDUCTORS

Q1 BC548
D1,2 TSIP5200 SEE BUYLINES
D3 8MM MIGH INTENSITY LED
IC1 MV500

CRYSTAL

XT1 500 kHz CERAMIC RESONATOR (MURATA)

MISCELLANEOUS

SWITCHES
SW1-SW8 PCB Mounting push to make See Buylines
2 Mounting clips for TSIP5200
1 Mounting clip for high intensity LED SEE Buylines
Box, Maplin TYPE LH90X
PP3 Battery clip

BUYLINES

All unusual components like the Infra red emitter and receiver diodes and mountings, the ultra-bright LED, the Clear mounting box for infra red reciever/preamplifier and the pushbuttons for the remote handset all came from Farnell Electronic Components

PART 2 NEXT MONTH

TELEPHONE ORDERS may be made on
(0442) 66551
ACCESS or VISA

Price code	Price (inc. VAT)
C	£1.80
D	£2.50
E	£3.25
F	£4.00
G	£4.75
H	£5.50
J	£6.62
K	£7.20
L	£8.80
M	£10.60
N	£13.10
O	£15.80
P	£17.90
Q	£21.80
R	£23.90
S	£25.90
T	£29.00
U	£32.20
V	£35.80
W	£37.90
X	£40.70

ETI
ELECTRONICS TODAY INTERNATIONAL

PCB Service April

E9304-1 Solo Mic Pre-Amplifier .... F
E9304-2 Multimate Tester C
E9304-3 The Keepsafe Alarm .... F
E9304-4 Proving Unit .... E
E9304-5 Infra Guide Receiver Module C
E9304-6 Infra Guide Transmitter .... F
E9304-FC (AutoMate) Peak Program Meter .... F

PCBs for the remaining projects are available from the companies listed in Buylines.
Use the form or a photocopy for your order. Please fill out all parts of the form. Make sure you use the board reference numbers. This not only identifies the board but also tells you when the project was published. The first two numbers are the year, the next two are the month.
Terms are strictly payment with order. We cannot accept official orders but we can supply a proforma invoice if required.
Such orders will not be processed until payment is received.

E9112-2 Nightfighter Sensor Switch Channel Control (2 sided) L
E9112-3 Nightfighter Sensor Switch Sound Trigger .... H
E9112-4 Nightfighter Connector Board .... F
E9112-5 Nightfighter Sensor Switch PSU .... K
E9112-6 Nightfighter 8-Channel Input Interface (2 sided) .... P
E9112-7 Power On and Overload Regulator .... P
E9201-1 Laboratory Power Supply .... F
E9201-2 Test Card Generator Board .... M
E9201-3 LED Star (2 sided) L
E9201-4 Enlarger Timer Main PCB (2 sided) .... N
E9201-5 Enlarger Timer Selector Board (2 sided) .... K
E9201-6 Enlarger Timer Switch PCB .... E
E9203-1 MIDI Switcher- Main Board L
E9203-2 MIDI Switcher- Power Suply .... E
E9203-3 Sine Wave Generator (surface mount) .... F
E9204-1 Auto Car Lights .... F
E9205-1 Bat Detector .... E
E9205-2 Pond Controller .... F
E9206-FC Stereo amplifier .... G
E9206-2 Xenon flash trigger Main Board .... J
E9206-3 Xenon flash trigger Flash Board .... F
E9206-4 Scanner for audio generator .... D
E9207-1 Improved Rear Bike Lamp .... D
E9207-2 Mini Baby Bug Monitor C
E9207-3 Ultrasonic Audio Sender (2 boards) .... H
E9207-4 Camera Add-on unit (4 boards) .... O
E9207-5 AutoMate 5V/48V Mixer power supply .... J
E9207-6 AutoMate Precision 17V power supply .... J
E9207-FC Surround Sound Decoder .... F
E9208-1 Dynamic Noise Limiter .... F
E9208-2 Touch Controlled Intercom (2 boards) .... H
E9208-3 MIDI Keyboard .... K
E9208-FC Battery charger .... F
E9209-1 Intercom for light aircraft .... H
E9209-2 Alarm protector C
E9209-3 Temperature controller .... M
E9209-FC 45W Hybrid power amp .... F
E9210-1 Universal I/O Interface for PC (2 Sided) .... N
E2910-2 Rapid Fuse Checker .... E
E9210-3 Heartbeat/Audio Listener .... E
E9210-FC Wizards Hat .... E
E9211-1 Electronic Die .... E
E9211-FC Car Alarm .... F
E9212-1 Digital Circuit Tester .... F
E9212-2 Communications Link by RS232 L
E9212-FC Mains Inverter .... E
E9301-2 Fading Festoonery .... G
E9301-FC Infra Red Receiver .... F
E9302-1 EPROM Programmer (2 Sided) .... N
E9302-2 Sound to MIDI Board L
E9302-3 Puddle Tec .... E
E9302-FC Infra Red Transmitter .... E
E9303-1 Ni-Cd Battery Charger .... E
E9303-2 IC Tester .... E
E9303-3 Disco Amiga (motor driver board) .... H
E9303-4 Direct Conversion Reciever (2 Sided) .... N
E9303-FC LED Stoboscope .... F

ETI PCB Service, Reader's Services, Argus House, Boundary Way, Hemel Hempstead HP2 7ST

Please Supply:

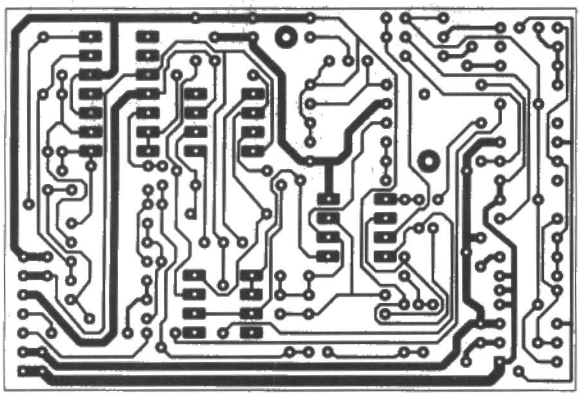
Quantity	Ref No.	Price Code	Price	Total Price
	E		£	£
	E		£	£
	E		£	£
			Post & Packing	£ 0.75
			Total Enclosed	£

Please send my PCBs to:
Name ....
Address ....
....
.... Postcode ....

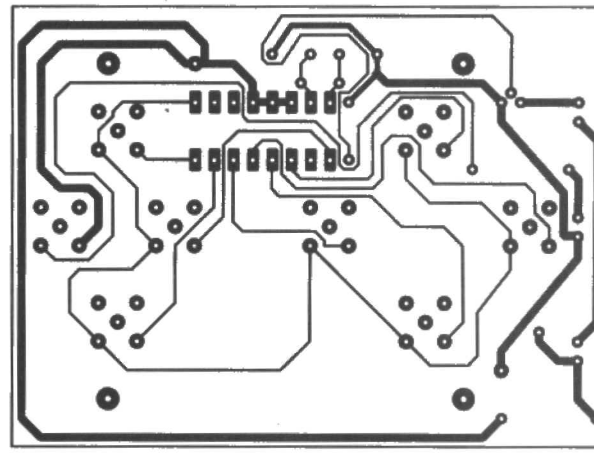
CHEQUES SHOULD BE MADE PAYABLE TO ASP Ltd.

PCB Foils

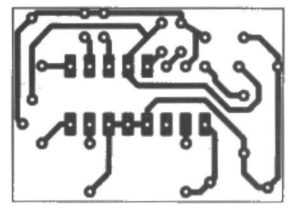
The PCB foil patterns presented here are intended as a guide only. They can be used as a template when using tape and transfer for the creation of a foil.



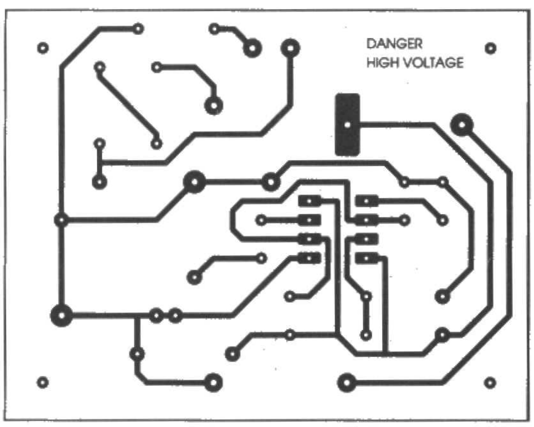
(AutoMate) Peak Program Meter



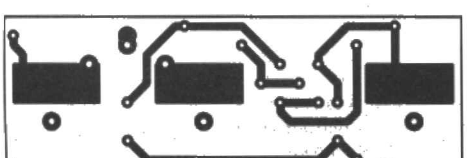
Infra-Guide Transmitter



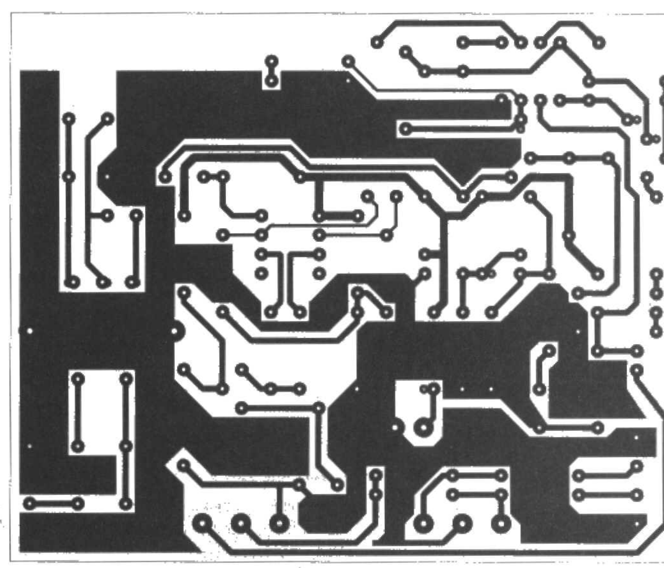
Infra-Guide Receiver Module



Proving Unit



Multimate Tester



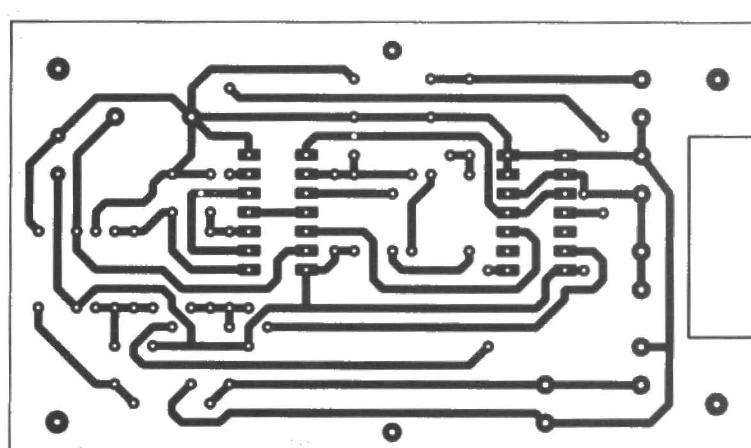
Solo Mic Pre-Amplifier

LED Stroboscope March '93

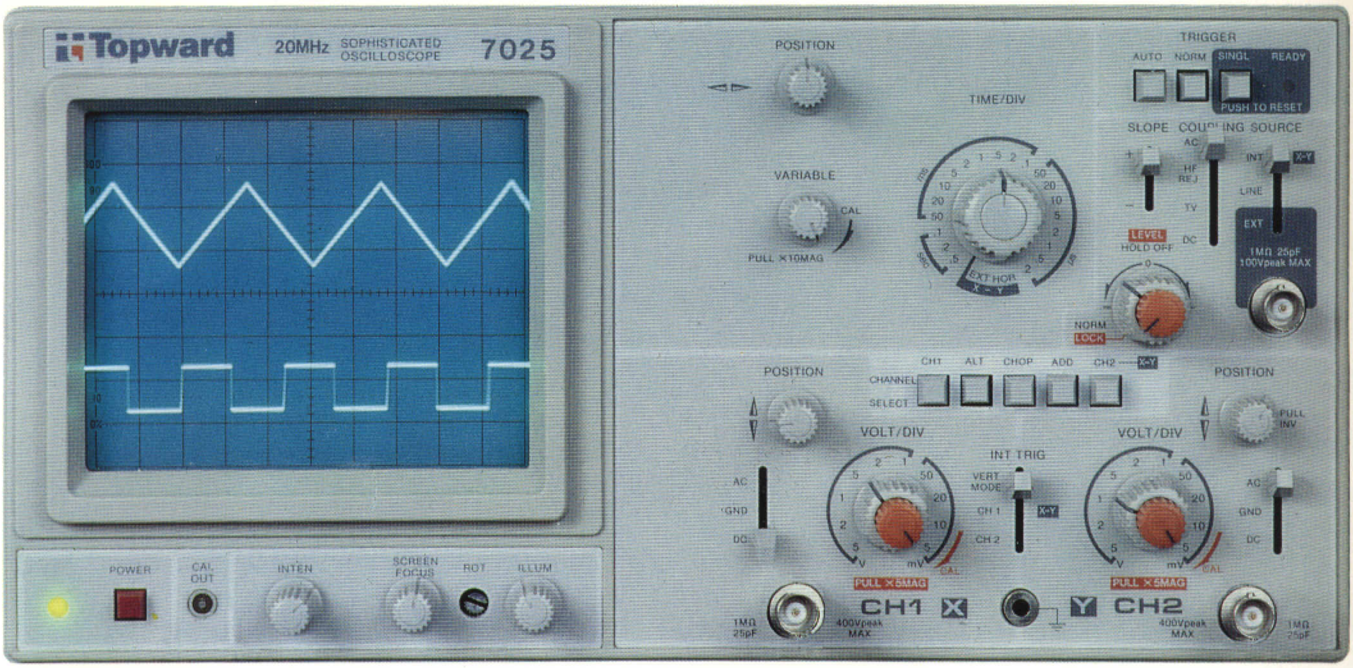
In Figure 2, R4 is given as 33R. It should be 330R as in the parts list.

Hybrid Line Amp Dec'92

In Figure 3, a horizontal line should be drawn between top of R3 and C5 (C6 in component overlay).



The Keepsafe Alarm



GL29G

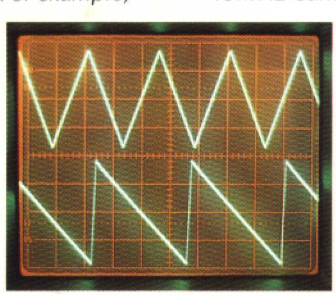
YOU WILL ALWAYS FIND MONEY SAVING BARGAINS AND LOW PRICES AT MAPLIN ELECTRONICS

Example NOW

SAVE UP TO *£100

ON OSCILLOSCOPES

*Due to Maplin's continued success and the popularity of our superb range of oscilloscopes, we are able to offer them at **SPECIALLY REDUCED PRICES,** but they are only available at these prices **AT MAPLIN STORES** for a **LIMITED PERIOD,** so hurry down to your nearest Maplin store TODAY! Advanced design and high quality manufacturing techniques have been combined to bring you, at a sensible price, all the features that you would expect of a sophisticated oscilloscope. For example, 1mV/div sensitivity, advanced 6-inch CRT with percentage markers and an internal graticule that eliminates parallax error, ensuring a highly accurate display, and an X-Y mode that produces Lissajous patterns for phase shift measurements. Type 7025 has all the features required for general purpose use and can display signals from DC to at least 20MHz with a high degree of accuracy. In addition to all the features of the 7025, Type 7026, has the added facility of a delayed sweep timebase, which can be used to magnify a portion of a waveform, making possible, accurate time interval measurements and the study of short duration events. The sophisticated Type 7045, has a bandwidth of 40MHz and incorporates a 40ns delay line to enable the display of very short duration events in their entirety. Top-of-the-range is the Type 7046, a delayed sweep oscilloscope with increased magnification along with a 40MHz bandwidth and capable of displaying complex signals with precision and accuracy.*



**** Please note: MONEY SAVING BARGAINS SHOWN ON THIS PAGE are applicable to purchases made in MAPLIN STORES ONLY and are not available at these prices through Mail Order.***

SAVE £100	7025 (GL29G) Catalogue Price £299.95	**NOW £199.95**
SAVE £20	7026 (GL30H) Catalogue Price £349.95	**NOW £329.95**
SAVE £70	7045 (GL31J) Catalogue Price £449.95	**NOW £379.95**
SAVE £40	7046 (GL33L) Catalogue Price £499.95	**NOW £459.95**

Rush to your local Maplin store: **BIRMINGHAM;** Sutton New Road, Erdington. **BRIGHTON;** 65 London Road. **BRISTOL;** 302 Gloucester Road. **CARDIFF;** 29-31 City Road. **CHATHAM;** 2 Luton Road. **COVENTRY;** 12 Bishop Street. **EDINBURGH;** 126 Dalry Road. **GLASGOW;** 264-266 Great Western Road. **ILFORD;** 302-304 Green Lane. **LEEDS;** Carpet World Building, 3 Regent Street. **LEICESTER;** Office World Building, Burton Street. **LONDON;** 146-148 Burnt Oak Broadway, Edgeware. 107-113 Stanstead Road, Forest Hill. 120-122 King Street, Hammersmith. **MANCHESTER;** 8 Oxford Road. **NEWCASTLE-UPON-TYNE;** Unit 4, Allison Court, The Metro Centre, Gateshead. **NOTTINGHAM;** 86-88 Lower Parliament Street. **PORTSMOUTH;** 98-100 Kingston Road. **READING;** 129-131 Oxford Road. **SHEFFIELD;** 413 Langsett Road, Hillsborough. **SOUTHAMPTON;** 46-48 Bevois Valley Road. **SOUTHEND-ON-SEA;** 282-284 London Road, Westcliff. Plus a NEW STORE opening soon in **MIDDLESBROUGH.** Phone **0702 552911** for further details. All items are subject to availability. All prices include VAT. Offer ends July 31st 1993.

Maplin ELECTRONICS